DOCUMENT RESUME

ED 171 570 SE 027 792

AUTHOR Stone, Larrie; And Others
TITLE Enhancing Science Instruction Through Photography.
INSTITUTION Nebraska State Dept. of Education, Lincoln.
PUB DATE 78
NOTE 95p.; Not available in hard copy due to copyright restrictions; Contains occasional light and broken type which may not reproduce well

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Curriculum Enrichment; Learning Activities; Photographic Equipment; *Photography; *Resource Guides; *Science Activities; Science Education; Secondary Education; *Secondary School Science; Teaching Techniques

ABSTRACT

This document is designed to provide teachers and students with a working knowledge of 35mm photography. Topics include Film Types and Filters, Camera and Lenses, Photomicrography, and the Darkroom. The Appendices contain science activities and projects for both teachers and students and a Bibliography provides additional sources of information. (MA)

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ENHANCING SCIENCE INSTRUCTION

through 35mm PHOTOGRAPHY

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"ENHANCING SCIENCE INSTRUCTION THROUGH PHOTOGRAPHY"

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A B

Figure 1: Identical photographs of a Cecropia moth demonstrating the relationship between f-stop and depth-of-field. (a) Photograph taken using a wide open 55mm lens (f-1.8) with a close-up attachment. (b) Same setup used in Figure a, but the lens was stopped down to f-16 in order to get more depth-of-field.

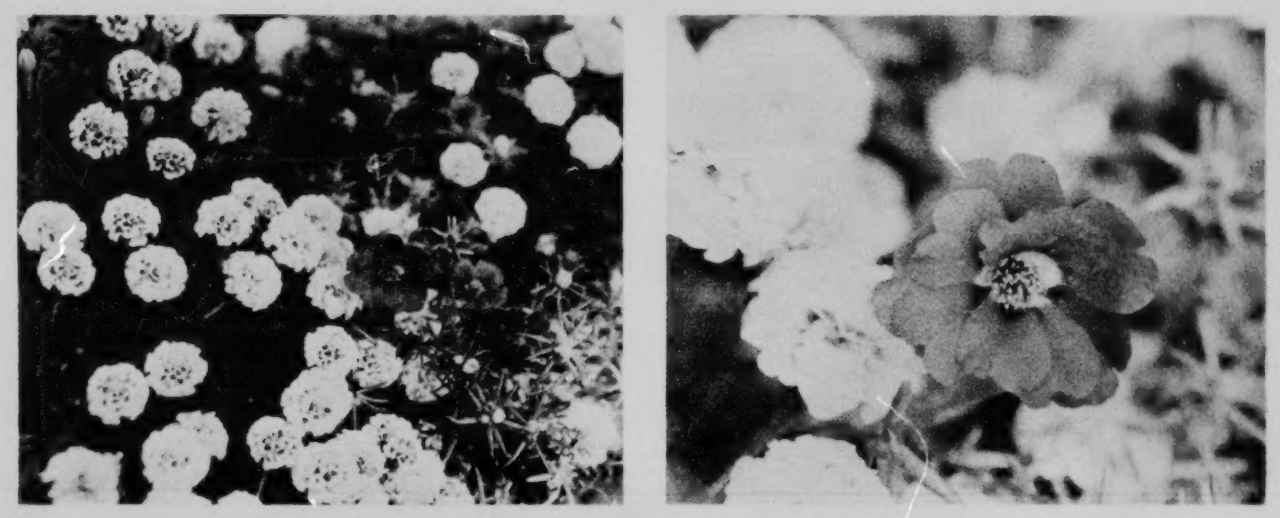

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Figure 2: Photographs of a flower bed taken from the exact same location to demonstrate the effect produced by lenses of different focal lengths. (a) Photograph taken with a standard 55mm lens. (b) Same area of the flower bed taken with a 135mm lens.

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FOREWORD

Numerous teachers across Nebraska have access to 35mm camera equipment. Often times this equipment is utilized more extensively for extra-curricular projects than for instruction. The intent of this publication is to provide the instructor with a beginning point from which to enhance instruction through the use of photography.

Dr. Stone has consolidated and written a manuscript which touches on the main topics and techniques needed to begin the use of photography in the classroom. The topics are explained in a style which is instructional both to the novice and to teachers with a working knowledge of photography. It is hoped that the information provided will answer numerous questions regarding technique and will provide the reader with the knowledge to begin a new perspective for science teaching in Nebraska schools.

The appendix section has numerous suggestions for both teacher and student use. The vast majority of the projects listed can be tied to the main manuscript for explanations of the technique needed to carry out the activity. Finally, an excellent bibliography is provided to assist the reader in locating sources of information and in seeking answers to questions not dealt with in this publication.

M. Anne Campbell
Commissioner of Education

ACKNOWLEDGEMENTS

It is indeed a pleasure to see the final compilation of this publication. A sincere thank you needs to be printed for Dr. Larrie Stone who put in a tremendous amount of effort and time to write this manuscript, and prepare the accompanying photographs. It has been a privilege to work with such a fine person in the development of this document.

The editor also wishes to express sincere gratitude to the numerous teachers that submitted articles for the appendix. Finally, a sincere thank you must be stated to Nancy Wipf for her excellent work in preparing and typing the final draft copy.

Don Woodburn
Science Consultant

INTRODUCTION

The main purpose of this manual is to provide the reader with some basic concepts of photographic technique and to introduce a variety of ways that photography can be used by both the student and teacher. In no way is this manual intended to be a complete guide to photography, but rather it is designed in the hope that the reader will discover information that will either be useful directly or provide a stimulus for further research into more advanced and complete literature on the subject. It is not possible to become a competent photographer by merely reading about various techniques and procedures. In order to become a good photographer, it is necessary to practice and learn by experience. Only then will you begin to discover the full enjoyment and potential of photography. The beginner should start by taking negatives of normal contrast to learn how to handle the average situation, and then progress to more complicated situations where experimentation and increased experience will provide the necessary tools to obtain superior results. One will quickly learn that there are often several ways that a particular photographic task can be accomplished, and the specific situation, personal preference, or desired results will often dictate the most satisfactory procedure(s) to use. Therefore, don't always be tied to the traditional procedures, but learn from experience the best techniques that will consistently produce the results that you need and desire.

Taking a photograph, developing film, and producing a finished print can all be tremendously exhilarating experiences. All of these processes rely on the use of special light-sensitive materials and a series of chemical reactions. Because photography literally means drawing with light, and since almost all aspects of photography involves some consideration of light - producing an image on film and paper, protecting the light-sensitive materials, or altering the light for special photographic effects - it is essential to be aware of its effects and properties in order to become a competent photographer and to receive the maximum benefit and enjoyment from your efforts.

Photographic films and papers have a support base coated with a light-sensitive medium (termed the emulsion) made up of minute silver halide crystals (usually silver bromide) suspended in a gelatin material. The exposure of silver halide to light produces a latent image which is reduced to metallic silver to form a visible image by the action of a chemical developer. The many minute grains of metallic silver form the black silver image of the negative or print. The developer will also attack unexposed grains of silver halide, but much more slowly so that the sensitized material must be stabilized after development to prevent "fogging" of unexposed areas. This is accomplished by fixing (with hypo) to remove the undeveloped silver halide crystals and then washing out the hypo to produce a stable and permanent emulsion.

Light is a complex phenomenon, and science has developed several models to assist in describing its various properties. Currently it is necessary to assign both the properties of wave motion and particle flow

to light in order to best explain all of its properties. That is, sometimes light behaves like a series of waves similar to those found on a pond when a rock strikes the surface of the water (except that the light waves vibrate in all directions perpendicular to the wave's direction of travel), while at other times light seems to behave like a flow or stream of particles (termed photons). A good physics textbook will provide the interested reader with a better and more sophisticated understanding of light and its various properties.

Visible light is part of a much larger band of electromagnetic radiant energy which includes such familiar radiations as the shorter ultra-violet, X-rays, and gamma rays plus the longer infra-red or heat waves and radio waves. The human retina is sensitive to the wavelengths from approximately 4000 angstrom units (deep violet) to circa 6500 to 7000 angstroms (red). Although the retina is not sensitive to the energies on either side of the visible spectrum (ultra-violet and infra-red), these energies can affect a photographic emulsion and produce an image or fog (X-rays used in airport security systems will also affect the film emulsion unless it is properly shielded).

The intensity of visible light used to strike the film determines the exposure needed to obtain a proper image on the photographic emulsion. It is usually measured by means of a photoelectric exposure meter either hand-held or built into the camera. The effects of a particular lighting situation depends on the size of the light source, its angle in relation to the subject of interest, and the amount of light available to fill in the shadows for additional detail. The typical light source is either natural (sunlight) or artificial (photoflood, flash unit, etc.), and its intensity ranges from bright light such as the noon day sun which is very harsh to dim light such as an early morning or late evening sun which is very soft and moody. This relative "hardness" (harshness) or softness of light has a direct affect on the appearance of the subject. A scene that is illuminated with a harsh or hard light, in which the rays are direct and parallel, will have a crisp, hard appearance. On the other hand, a scene illuminated with a soft, diffuse light, in which the rays are broken up, scattered, and no longer parallel, will produce an image that has a softer and more gentle appearance. A soft light can be produced artificially by placing a diffuser over a reflector fitted with a photoflood bulb.

The direction of the light striking the subject determines the shadow pattern, controls the contrast, and to some extent the depth effect of the final photograph. The main types of lighting used in photography are front-lighting, sidelighting, backlighting, toplighting, and underneath lighting, and they can be used separately or in combination to provide a multitude of creative effects for different needs and situations. For example, using two floodlights set at 45 degree angles to the subject, using light from a single photoflood positioned to the side of the subject and directed to bounce light off of a background wall, or using two floodlights pointing at one another set equal distance from the subject and set on the same plane as the subject all produce different and interesting affects. Lighting can prove to be an invaluable technique in attempting to create that very special effect to produce the results that you desire. The creativity that different lighting techniques can provide the photographer is both valuable and exciting. A relatively inexpensive and helpful booklet describing some lighting principles is Petersen's Guide to Photolighting

Techniques by Ben Helprin and the Editors of Photographic Magazine (Petersen Publishing Company).

In situations where there are very heavy shadows that decrease the amount of detail, one can use fill-in illumination to lighten the dark areas and increase the amount of detail visible. In outdoor situations a flash can be used as a fill-in light, while indoors a photoflood lamp with a reflector or a flash can serve this purpose. For example, using a flash to bounce light off of a light colored ceiling gives a soft fill light that will highlight the features of the subject being photographed. Sometimes it is desirable to use extra illumination to simply lighten the entire general background of a scene.

It is sometimes necessary to observe a particular subject for a prolonged period of time, and also at the same time take periodic photographs for a permanent record of the observations. If the subject is not bothered by either strong or continuous light, there aren't any significant problems. However, if the subject is sensitive or irritated by continuous or strong light, then it might be necessary to utilize the available light with a combination of fast film and wide open aperature, or an extra light source may have to be utilized at the moment of exposure. The latter can be accomplished either by using a single flash unit (or a multiple flash unit series), or by utilizing a series of strategically placed flood lights that are controlled by a central switching unit, and can be switched on and off quickly at the time of exposure.

Each type of light source used (flash, photoflood, morning sun, noon sun, overcast day, etc.) has its own color characteristics, even though each may appear to the eye as being "white." It is especially important to be aware of this fact in color photography in order to get an appropriate color rendition of a specific scene. The proper use of filters in this connection is very important in order to "correct" the light source to make it compatible with the film type being used (see Kodak Photo Book - Filters and Lens Attachments; AB-1). Filters and special attachments are also important in both color and B & W photography to produce better contrast, creative effects, and special applications. For example, in B & W photography an orange filter will create dramatic contrast between blue sky and clouds, flowers, and foliage. In portraiture work a green filter can help B & W film render an exact tonal reproduction of the skin as the human eye sees it, as well as increases the contrast between blue sky and clouds. A medium blue filter is required to convert daylight type color film for use with 3400 degrees K photoflood lighting. Pictures taken under these conditions without the proper filter will have a prominent yellowish cast. Filters and other special attachments come in a wide variety of types and sizes that will screw into the front of most lenses.

CHAPTER I
EXPOSURE

In order to produce a high-quality photograph or color transparency (slides used for projection), it is necessary to determine an accurate exposure. A correct exposure is obtained when the quality and quantity of light used to expose the emulsion produces B & W negatives with a normal range of densities (black-gray-white), color negatives with the proper range of densities and color relationships, and color transparencies with colors that are pleasing and faithful renditions of the scene photographed. An overexposure is caused by too much light and produces B & W and color negatives that are very dark and dense, or color transparencies in which the color is too light or completely washed out. An underexposure is caused by not having enough light and results in B & W or color negatives that are too light and washed out looking, or color transparencies in which the color is too dark and the overall scene very dense.

In photography exposure is determined by multiplying the INTENSITY of the light used by the TIME the emulsion is acted upon by the light (EXPOSURE = I X T). This means that light intensity is the reciprocal of the time, and further implies that the exposure needed for a specific result can be obtained by either increasing the light intensity and decreasing the time or decreasing the light intensity and increasing the time as long as the product of light intensity multiplied by time remains the same. In photography these two variables are controlled by the diaphragm in the camera lens (a series of overlapping metal leaves that form a roundish opening), and the shutter speed control found in the camera body of the typical single-lens reflex camera. The diaphragm functions to control the intensity of the light striking the film (it also controls the depth of field - see page 5), while the shutter mechanism controls the length of time that light is allowed to strike the film (it is also important in stopping the action in your pictures in order to increase sharpness in motion shots. See example of the water pitcher on front cover.)

The aperture size of the typical lens is expressed by a ratio obtained by dividing the lens focal length by the diameter of the diaphragm opening. The focal length of a lens is the distance between the point in the lens where the image is formed and the point where the image is brought to a sharp focus. The aperture size is expressed by the term f-stop or number, and each consecutive f-number is calibrated in such a way that each higher number requires twice the exposure of the preceding number. In other words each successive higher setting halves the amount of light of the previous setting that is able to enter the lens. The typical scale of f-numbers is a sequence as follows: 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, and 32. Some cameras do not have all of the series mentioned and some may also have half-stops between two standard f-numbers. The smaller the f-number the larger the lens opening, and a lens stopped down from f-4 to f-5.6 will require twice as much light in order to get the same exposure or negative density. An f-1.4 lens is considered a very fast lens and a high-quality lens with this large of a maximum aperture will prove to be very expensive, but a good investment for the photographer who wants a great deal of versatility in low light situations. The speed of a lens

refers only to its aperture size, while the shutter speed refers to the length of time that light is allowed to strike the film.

The shutter speed on most cameras usually ranges from 1 second to 1/500 or 1/1000 of a second. A good quality camera body will be able to reproduce the various speed settings with a great deal of accuracy. A sequence of shutter speeds seen on the typical single-lens reflex camera (SLR) is B, 1, 2, 4, 8, 15, 30, 60, 125, 500, and 1000. The 1 setting is a full second, while the other numbered settings correspond to fractions of a second (e.g. 1/2, 1/4, etc.). The B (bulb) setting holds the shutter open as long as the release mechanism is kept depressed, and requires some alternate method of timing such as a stopwatch, sweep second hand on a watch, or simply counting.

The slower shutter speeds are useful for situations where the amount of light available is at a minimum, while the faster shutter speeds are useful to arrest movement in the subject being photographed in order to prevent blurring. At a shutter speed of 1/30 of a second or below, it is virtually impossible to hand-hold a camera without some movement. Also lenses larger than 135mm are relatively long and heavy, which makes hand-holding more difficult plus the fact that they bring distant subjects up close which also magnifies even the slightest camera movement. Therefore, when using long lenses or shutter speeds of 1/30 second or less, it is important to hold your camera rigidly on some solid support such as a chair back, a table top, a rock, a fence post, etc. or better yet mount it on a good quality, sturdy tripod. When using a tripod or mounting the camera on a microscope or copy stand, it is always desirable to use a cable release in the shutter release mechanism, which will disturb the set-up as little as possible during exposure.

The diaphragm of the lens is not only important because it controls the intensity of the light striking the film, but it also determines how much of the viewing field will be in sharp focus for a particular exposure. When you focus your camera on a subject some parts of the scene will be in sharp definition or focus at the level of the film, while other parts are not. The region of sharp definition around the subject position is referred to as the depth-of-field. In general, one can state that the smaller the diaphragm aperture of the lens (f-stop) the greater the extent of the sharply covered zone in depth, and the larger the aperture opening, the less will be the zone of depth or sharp focus. Figure 1 shows the anterior region of a Cecropia moth taken under identical conditions except that the photograph on the left was taken at an aperture setting of f-1.8, while the one on the right side was taken at an aperture setting of f-16. Note the greater depth of sharp definition that was obtained when the lens was stopped down to its smallest aperture. It should be obvious from the earlier discussion that the photograph on the left was shot at a faster shutter speed than could be used when the lens aperture was stopped way down. Opening up the lens to its widest aperture can be very useful when your subject of interest is associated with a poor or unwanted background since this will give a sharp subject, while at the same time softening the background so that it is less conspicuous. In general most lenses produce sharper pictures when they are not used at their widest aperture, but rather slightly stopped down.

Sometimes it is important to get the maximum sharpness for a certain depth-of-field, but to do so with a minimum of stopping down the aperture of the lens in order to retain a faster shutter speed. Using a lens equipped with a depth-of-field scale, focus on the most distant subject in the field to be photographed, and note the distance from the camera using the distance scale found on the lens barrel. Repeat with the closest subject in the field to be photographed and then refocus the lens until the same diaphragm stop numbers appear on the depth-of-field scale opposite the foot-numbers (or meter numbers) that correspond to the beginning and end of the sharp zone to be photographed. Leave the lens in focus, set the camera to the f-number indicated above, and then take the picture. This will give maximum sharpness for the desired subject field with the least amount of stopping down, hence giving the fastest shutter speed that the restrictions on depth-of-field will allow. Notice that the depth-of-field range is less with very close subjects and greater as the subjects get farther from the lens.

When determining what exposure to use for a particular subject, it is necessary to consider how much light will be needed by the film in order to provide the desired contrast with adequate detail in the darker areas of the print, how much depth-of-field is desired, and if the subject is in motion, how fast must the shutter speed be in order to "stop" the action and prevent blurring. Choosing the f-number and shutter speed for a suitable exposure is not just a random choice of what will work, but rather a carefully selected combination that will produce the desired end results. These are some of the basic reasons why the serious photographer wants a camera with a "fast" lens, multiple f-stops, and a wide range of shutter speeds plus the availability of a wide choice of film types with a variety of film speeds (ASA numbers).

When you are in a must situation to get an acceptable photograph the first time, or when you are photographing a very transient subject or a scene that has a difficult lighting situation, such as a bright sun set, it is desirable to bracket your exposure by taking several different shots. When using color film it is usually desirable to bracket your initial exposure by taking at least two additional exposures at settings that are 1/2 to 1 f-stop higher and lower than the exposure indicated by your meter as being normal. Since black and white film has much more latitude than color film, the bracketing will probably have to be 1½ to 2 f-stops higher and lower than the normal exposure. The determining factors for how much you need to bracket your initial exposure will depend on the film speed being used, type of film, lighting conditions, and general experience of the photographer.

CHAPTER II
FILM TYPES AND FILTERS

In order to be successful in photography, it is important to begin by choosing the most suitable film for the particular subject and/or result desired. Photographic films come in a variety of sizes and types that provide the photographer with a range of color sensitivity, speed, and definition. Essentially film consists of silver halides (bromide, chloride, and iodide) suspended in a gelatin emulsion that is supported on a special base such as glass, celluloid, or estar. In a pure state the silver halides are relatively sensitive to ultraviolet and visible blue light, but relatively insensitive to the rest of the visible spectrum. Most papers used for making prints from B & W negatives are prepared using silver halide emulsions attached to a paper base without much modification. This means they are relatively slow (require a relatively large amount of light for proper exposure), and sensitive to only the blue range of the visible spectrum. Therefore, photographic papers can be safely handled under a red or yellow safelight without fogging the emulsion (safelights do have some limitations and should be used with certain precautions). Films are much faster than papers, and can be made sensitive to a wider range of the visible spectrum, increased in speed, and modified for a variety of characteristics, such as contrast and grain size, by specific manufacturing techniques that includes mixing halides, adding sensitizing chemicals, "ripening" the emulsion with heat, etc.

Black and white films can be classified on the sensitivity of the emulsion as follows: ordinary - sensitive to blue wavelengths; orthochromatic - sensitive to blue and green wavelengths; and panchromatic - sensitive to all visible colors of light. Therefore, it is possible to handle ortho films under a red safelight, but pan films are generally sensitive to all colors, and must be handled only in total darkness.

Film speed is a term that describes the sensitivity of the film emulsion to light, and should not be confused with lens speed. The ASA number (The American Standard Association) or Din number (Deutsche Industrie Normen) are two common systems of rating film speeds that are standard in the United States and Germany respectively. The higher the rating number the faster or more sensitive is the film emulsion to light. This means that a film with an ASA of 400 will require only one-half as much light for exposure as a film with an ASA of 200. The advantage of the faster film over the slower one is that it can produce the same exposure with a faster shutter speed to stop motion and/or a more "stopped down" lens setting to get a greater depth-of-field. On the other hand, in comparison to the slower films, the so-called fast films have some characteristics that may be undesirable in certain situations. For example, their grain structure is more coarse due to the silver being in clumps instead of evenly distributed in the emulsion, which becomes very apparent as images of the clumps when an enlarged print is made from the negative. Also the faster films tend to have less contrast, or in other words, the gradation of densities between adjacent areas is low. Therefore, when deciding what film speed to use for a particular photographic situation, it is wise to use the slowest film that is just fast enough to do the desired job, unless

the presence of grain produced by the faster films is desired for some special effect. For example, a B & W picture of a low-light scene might require the high speed of Kodak Tri-X film (ASA rating of 400), although it might mean a sacrifice of contrast and produce more graininess than a slower film. On the other hand, if adequate light is available, Plus-X (ASA rating of 125) might be more appropriate since it has a finer grain and more contrast than Tri-X film, which would permit a high quality print even under the stress of significant enlargement.

From the above it is obvious that many factors must be considered when selecting a film type for a specific photographic situation. Although the tremendous variety of film types (e.g. color sensitivity, speed, grain size, contrast, etc.) available in the 35mm foremat is of significant advantage to the serious photographer, a distinct disadvantage is the small dimension of this film size. The latter characteristic makes it difficult to get large prints that are technically of satisfactory quality because excessive enlargement promotes grain and lowers contrast. However, the relatively low cost of this film size and the tremendous versatility of the 35mm camera system make this foremat very attractive for the majority of photographic situations.

There are two basic types of color films termed reversal color film and negative color film. The reversal color films yield positive color transparencies that can be viewed directly, projected by transmitted light, or used to make color prints on paper. The negative color films yield negatives that must be printed directly on paper like B & W negatives. It is more difficult to shoot pictures in color, since color films have less latitude in exposure than do B & W films, plus the color photographer must be concerned with the color values of the light being used to expose the film. Each color film type is balanced for a specific type of light, and when the wrong combination of light and film are used the colors will appear more or less unnatural. Daylight film is corrected for a combination of direct sunlight that is more than twenty degrees above the horizon and blue sky containing several white clouds. Therefore, pictures taken in early morning or late evening light may have a slightly improper color balance unless the right filter is used to correct the light (an overcast sky, open shade, etc. would also differ from standard daylight). For someone who is just taking some general pictures, these differences in normal daylight situations may not be critical, but for the serious photographer, who desires highly accurate color rendition, these subtle differences can be of great significance. By using one of the many filters available for color films, the color quality of the light source being used can be corrected to get the proper color rendition for the film being used or to create a variety of special effects. Artificial light is even more variable than daylight, since an electronic flash, a photoflood light, an ordinary household light bulb, a fluorescent light, etc. all have different spectral energy distributions, and give slightly different results on color film intended for use with artificial light.

Although the creative manipulation of light is extremely important for quality color photography, it can also be very important and rewarding in B & W photography. For example, the proper filters can increase the contrast between sky and clouds or lighten foliage and darken flowers. Another useful filter is the UV-haze type which can be used at all times and under all conditions. It will eliminate the ultra-violet light to

which the film is sensitive, but it doesn't have any affect on the light that is visible to the naked eye. It also serves as an inexpensive way to protect the surface of a high quality lens on the camera from getting scratched or otherwise damaged.

Another very useful filter type is the polarizing filter, which consists of two polarizing elements in a single mount that permits the outer element to be rotated in order to obtain the polarizing effect desired. This filter affords the photographer a means of controlling light selectively without affecting the color balance, and it can be used successfully with both color and B & W film. There aren't any visual differences between a beam of polarized light and one which is not polarized. The polarizing filters are used to reduce the glare and reflections from water, glass, and other non-metallic surfaces. With through-the-lens viewing, one can see the results of the polarizing filter and adjust the two elements as desired. For example, a polarizing filter provides a clear, sharp picture without glare of such things as the inside of an aquarium, the organisms in a shallow tidal pool, or someone standing behind a large window that is bathed in glare. When using color films, this type of filter can also be used to increase color saturation and darken blue skies.

Since the film you choose for a specific situation is the starting point for the production of almost any finished photographic product, it is good common sense to handle it with a great deal of care. Always load the film into the camera in subdued light, and be sure to register the type of film somewhere on the camera body (some cameras have a special film indicator knob to record the common types of film, but on cameras lacking this feature a piece of tape with the film type, ASA number, and date of loading can be mounted on the back of the camera). After the last frame on the film has been exposed, immediately rewind the film back into the cassette before any accidental opening of the camera case might ruin it. When removing the cassette mark it "exposed" with a felt pen and/or a piece of tape, and keep it in a standard place separate from unexposed film until it can be developed.

All films gradually deteriorate with age no matter how carefully and correctly they are stored. Color film is more sensitive to damage than B & W film due to the many color sensitive dyes incorporated into the emulsion. Heat is very damaging to film, and excessive heat, such as leaving your camera or rolls of film in a closed automobile on a hot, sunny day, should be judiciously avoided. Films as well as photographic papers can best be stored for long periods of time in a refrigerator or deep-freeze unit, but they must be sealed in a moisture-proof container or bag. The original, unbroken moisture-proof container around most films is adequate, but unpackaged film and all photographic papers must be stored in waterproof bags or containers using tight lids sealed with waterproof tape. Also prolonged exposure to the vapors of most laboratory solvents and other volatile chemicals should be avoided as well as exposure to X-rays and radioactive materials.

It is also a good practice to get film developed as soon as possible after it has been exposed since the exposed film is more susceptible to damage by various agents than is unexposed film. It is also a good idea to avoid leaving a partially exposed roll of film in a camera for excessively long periods of time.

There will be times in the life of every photographer when the available light is relatively dim, and even high speed film isn't fast enough, or the conditions require an undesirable combination of f-stop and shutter speed to get an acceptable exposure. Under these conditions one might consider exposing some films at a film speed (ASA number) higher than their normal rating and then "push-processing" the film during development. This apparent increase in film speed will give you additional latitude and versatility in low light situations where you want to stop-down the lens and/or use a relatively fast shutter speed, or when accessories such as those utilized in close-up photography, photomacrography, photomicrography, etc. demand more light than can be provided. Some examples of where this might be useful would include such things as taking photographs (either B & W or color slides) of school plays using only the stage lighting, action pictures of indoor sporting events and night football games, taking a series of photographs demonstrating the behavior pattern of some animal species without using bright lights that might disturb the animals, etc. However, before deciding that this might solve all of your problems associated with dim lighting conditions, it must be remembered that a film produces results of the highest quality only when you expose it at its recommended film speed and process it according to normal development procedures. In general, the underexposure (increasing ASA rating) to take the pictures and push-processing to develop the film will reduce some quality in tone reproduction and increase the overall graininess. This reduction in quality is often acceptable when the increased film speed is highly desirable, or when it is the only way to get a photograph due to exposure limitations.

All black and white films and some color-slide films can be push-processed during development to yield a higher film speed rating. For color slides this special processing can best be done for a small additional charge by certain laboratories specializing in custom work. For example, when purchasing a prepaid processing mailer for Kodak Ektachrome film, it is possible to buy, in addition, a special processing label that can be sent in with the film and regular mailer. This will permit you to expose the entire roll of film at double the effective speed of the Ektachrome film being used. It is much simpler to push process B & W films since all that one needs to do is increase the development time for the film. For example you can shoot a roll of Kodak Tri-X B & W film at a film speed of 800 instead of its normal rating of ASA 400. The exposed film is then push-processed by increasing the development time recommended on the film instruction sheet by 50 percent for any of the developer combinations listed, except for Microdol-X Developer which should not be used. To produce acceptable prints from these negatives you will probably find that the lower contrast papers will produce prints with poor shadow detail, but they will probably have very acceptable detail in the highlights and middle tones. It must be remembered that all the shots on one roll of film must be exposed at the same increased ASA rating if the film is going to be push-processed.

CHAPTER III
THE CAMERA

The camera is basically a light-tight box that holds the lens and retains the film, plus it houses the mechanisms for film advancement, the shutter mechanism, the timing device, light meter, etc. Going to the photography market to buy a camera is a bewildering experience due to the hundreds of cameras to choose from, the wide range of prices, and the high powered advertising claims of the various manufacturers. The best camera for the serious photographer is the one that has the necessary features for the types of photographic situations that will be encountered at a price that is compatible with the budget available. If a very basic outfit is purchased to save money, be certain that it will accept the types of accessories that you may want to add at a later time.

The single-lens, 35mm reflex camera (SLR) is the most versatile and popular type on the market today, and for the types of techniques and procedures described in this manual, it is the most preferred camera. In spite of its several disadvantages the SLR camera offers the most adaptability to the greatest variety of subjects, and it is especially flexible for coping with the diverse types of procedures presented in this manual. The wide range of accessories permits one to deal with subjects ranging from the microscopic world to the telephotography of very distant subjects. The reflex design involves mirrors and prisms that projects the image formed by the lens to the view finder, which makes it possible to both view and focus the subject as it will actually be registered as an image on the film. It also permits one to directly view any pictorial effects such as those produced by multiple image or soft-focus filters. Most SLR cameras use a focal-plane shutter, which is a slotted curtain of cloth or metal that moves across the film to expose it when the shutter release mechanism is pushed.

Single-lens reflex cameras also feature interchangeable lenses (bayonet or screw thread mount) with a variety of different focal lengths and speeds. This permits the rapid switching of lenses in order to increase the versatility of your camera system - for example, one could use a 28mm lens to get a wide angle view of a building and its surroundings, and then within seconds switch to a 400mm lens to get a full frame shot on some portion of the building such as the fancy molding around one window without moving from your location (see Figure 2).

In addition SLR systems permit metering directly through the lens, and most SLR's on the market today come equipped with a built-in reflected light meter (measures the amount of light reflected from the subject), which measures the amount of light coming through the lens. Some through the lens (TTL) meters take an average reading over the entire field of view (averaging type), while others emphasize only the central portion of the field (center-weighted type). While satisfactory for the majority of situations the built-in meters do have some limitations, and many professionals utilize hand held meters for special situations and problems that might be encountered or when attempting to achieve special effects under very difficult situations. One big advantage of the TTL metering

system is that it responds to the brightness of the image as seen by the camera lens. This means that the meter will automatically register any change in the amount of light entering the lens due to the use of close-up accessories and/or special filters. This automatic exposure correction makes the use of lens accessories much easier and more accurate. Exposure tables are sufficiently accurate for most average situations that will confront the photographer, but an exposure meter (either built-in or hand held) is absolutely necessary for precision work. A meter provides a reading of the over-all illumination of a scene as well as an accurate evaluation of the light and dark areas of the scene in order to get the best possible overall exposure.

A 35mm camera that is equipped with an automatic diaphragm has a distinct advantage when taking pictures in rather dim light, or in other situations where viewing is difficult. In the automatic position the fully automatic diaphragm is at its largest aperture at all times, except for the time of exposure, no matter what aperture (f-number) is set on the lens diaphragm ring. When the shutter mechanism is released, the diaphragm automatically stops down to the pre-set diaphragm setting, and the shutter opens for exposure. After the exposure is completed, the diaphragm automatically reopens to maximum aperture, and you are again ready to shoot your next picture. You can visually check the exact depth-of-field at any time by moving the diaphragm control from automatic to manual. In situations where you are taking pictures in very bright light, the diaphragm can be left in its manual position in order to compensate for the light by stopping down and to provide a constant check on the depth-of-field.

Most SLR's have a self-timer mechanism on the front of the camera body. It consists of a cocking lever that can be set to release the shutter after several seconds of delay. The camera can be mounted on a tripod, focused, set for the proper f-stop and exposure time, and then the self-timer started. The several seconds of delay before the shutter trips can then be used to get yourself into the picture or to make some special adjustment in the scene to be photographed that can be done only at the last second. When taking a picture that includes only the photographer, the focus can be established by getting an object in the scene that will be at the same level as the subject into sharp focus.

Some of the advantages of the 35mm camera are: (1) it is of small size, lightweight, and relatively inconspicuous for candid work; (b) the relatively low cost of 35mm film and a wide variety of film types and characteristics to choose from permits more complete coverage of a subject at a nominal cost and the opportunity to be creative and experiment with different film characteristics; (c) the availability of a variety of accessory lenses that gives the choice of many different focal lengths and lens speed (the latter permits obtaining good images even in situations where the lighting is poor); (d) the availability of numerous camera accessories and attachments that provides the photographer with a variety of ways to accomplish a particular task or to complete very complex photographic assignments - such items as special effects filters, extension bellows, close-up lenses, microscope adapters, etc. all provide a freedom of flexibility that can make photography a useful tool for a multitude of situations; and (e) the basic camera can be found in a variety of price ranges and styles to fit the needs of most photography enthusiasts.

There are also disadvantages that must be weighed against the advantages, while keeping in mind the needs being served by the camera and the accessories available. The very fact that it uses 35mm film can be a serious disadvantage for certain needs. As indicated previously, the film is only 35 millimeters in width, which has advantages for camera design, but does not provide a large negative for print enlargement or transparency for projection.

When you are ready to purchase a camera begin the process by reading technical reports on the various models available in your price range in such magazines as Popular Photography, Modern Photography, and Petersen's Photographic Magazine. Back issues of these magazines can usually be found at the public library. It is also a good idea to ask questions of a competent salesperson at a reputable photography outlet and/or seek information from a local free-lance or knowledgeable amateur photographer.

Before making the actual purchase be sure to compare prices from several different sources in order to obtain the best buy. In comparing prices for a specific model be certain that each deal includes the same accessory items and lens (e.g. focal length and lens aperture). If you order from an advertisement in a magazine, be certain that the mail-order house is reliable. It may be difficult to decide which companies are reputable, but asking other photographers who have ordered from various places may help in making your decision.

If your budget will not permit you to buy the new camera that is desired, you might want to consider purchasing used camera equipment. This is obviously more risky than buying new equipment since you will not receive a guarantee from the manufacturer. If you are looking at used equipment from a local camera store, be sure to buy from one that gives a reasonable guarantee. If it is at all possible, try to check out the camera and/or lens by shooting several rolls of film and carefully examining the results for lens aberrations, lens defects, camera malfunctions, etc. If you are buying from an individual person, then the trial period for shooting a couple rolls of film is of the utmost importance. It is also advisable to carefully check the camera for excessive hard use and/or wear, and to be certain that the lens fits tight in the barrel, does not have any scratches, and that the threads or bayonet mount does not show excessive wear or damage.

CHAPTER IV
LENSES

A modern top quality camera lens is made from a highly ground and polished disc of glass whose opposite faces are sphere shaped and coated with a material that reduces the intensity of flare light within the lens. Most SLR cameras come equipped with a relatively high speed lens of about 55mm focal length, that is composed of a series of 4 to 8 carefully selected simple positive and negative elements assembled into an intricate mount to produce a compound lens with optical defects (e.g. aberrations such as color, spherical, etc.) reduced to practical limits. Each lens usually has a diaphragm that can vary the amount of light that passes through the lens. The size of this opening is indicated by the f-number, with the smallest number being the widest aperture available, and the largest number the smallest opening to which the lens can be "stopped" down. Therefore, the speed of the lens is indicated by the smallest number or largest aperture opening that the lens can produce, and it is one of the qualities of a fine lens that can be a significant factor in the cost.

A lens with several elements not only has optical aberrations that must be taken into account during manufacturing, but also produces reflections of light back and forth between the surfaces of the lens elements termed flare. Most modern lenses are coated with a metallic compound that increases light transmittance and reduces lens flare. Good lenses are also color corrected for chromatic aberrations which result from the fact that when white light passes through a prism or a lens the colors of the light are separated since the index of refraction differs slightly for different colors. This variation in refraction leads to chromatic aberrations because the different colors are brought to a focus at different points and produces a poor image. With the proper combination of lens elements a lens can be color-corrected so that it focuses all colors or wavelengths close enough together to meet normal photographic demands. A lens corrected for two colors is termed achromatic, while one corrected for three colors is termed an apochromatic lens. Generally, correction for two colors is more than adequate for the majority of photographic projects.

Light reflected by the subject and the immediate surrounding field is the only light that should enter the lens and expose the film. Other light represents potential lens-flare and fog, and the lens should be shielded from this stray light. Many long focal lengths lenses have a built-in lens shade to shield the lens from unwanted light. Other lenses must use a removable, threaded lens shade that usually can be mounted directly on the lens or mounted on the filters already screwed into the lens. A good lens shade can also protect your lens not only from fingerprints, but also from such inconveniences as rain, splashing water, snow, etc.

A preliminary discussion of the concept of f-stop can be found in Chapter I. Involved with determining the f-number formula is the focal length of the lens. With a 35mm camera one generally considers a lens

with a focal length of 35mm or less as a short focal length lens (wide-angle lens), while one of 90mm or longer is considered a long focal length. A lens of long focal length is often termed a telephoto lens although this term is technically reserved for a particular kind of optical arrangement that has a positive front lens and a negative rear lens. This permits the physical length of many telephoto lenses to be shorter than the actual focal length of the lens. In this publication all lenses 90mm or longer will be termed telephoto since it has become fairly common practice to do so. With the same camera-to-subject distance, the size of the image produced on the film is directly proportional to the focal length of the lens being used. Therefore, a 200mm lens will produce an image on the film that is four times the size of the image produced by a normal 50mm lens when the photographs are taken from the same location. The shorter focal length lenses are very useful for situations where it is necessary to include a great deal of the scene, and you are limited by the distance that the camera can be from the subject of interest (e.g. taking a picture of several people in a very small room). The wide angle lens also permits the photographer to get very close to the subject of interest, but care must be taken not to get a distorted perspective of the scene. This can happen with a wide-angle lens because the lens exaggerates space relationships by extending the apparent distance between objects close to and distant from the lens. This can be advantageous in producing a special effect by exaggerating the size relationships between some object in the foreground and one in the background.

The long lenses or telephoto lenses are ideal for the nature photographer and others who have the problem of great distance from the camera to the subject being photographed. In photos taken with a long lens, the image appears to have been photographed from close range, while on the contrary it was actually taken from a greater distance (see Figure 2). Enlarging a relatively small section of a negative produced by a normal range lens (e.g. 50 or 55mm) will give the same results as a long lens, but the limitations are obvious since enlarging a small segment of a 35mm negative to any significant degree will produce a lack of clarity and obvious grain.

The very long focal length lenses are heavy and magnify even the slightest camera movement which makes it imperative to provide a firm support for the camera when taking pictures with a long telephoto lens. Another factor to consider is the smaller maximum aperture opening that most longer lenses possess which makes them relatively "slow" in comparison to the shorter focal length lenses. This generally means using a fast film to compensate for the light loss due to the higher f-numbers of these lenses unless ample light is available to utilize the slower films. In situations with limited light even the fastest films may not be fast enough to permit much "stopping" down of the lens which might limit depth of field or stopping subject movement.

A relatively inexpensive way to have the advantages offered by possessing lenses of several different focal lengths is to invest in a lens-extending device termed a tele-converter. This attachment is inserted between the lens and camera body and because the tele-converter is a negative component that causes the light rays to diverge, it enlarges the image and thus increases the effective focal length of the lens attached to it. They are available in a variety of powers such as 1.5X, 2X, and

3X, which would convert a standard 135mm lens into a 202mm, 270mm, or 405mm focal length lens. In combination the 2X and 3X entenders would provide a system with a focal length increased by a factor of five times. In addition to increasing the focal length of a lens the tele-converter will also decrease the effective aperture of that lens by the same factor as the increase in focal length. For example, a 135mm, f-2.5 lens will have an effective aperture of f-5.0 with a 2X extender. Avoid the cheap tele-extenders since even the more expensive and high quality extenders generally do not produce pictures that are equal in quality to ones produced with a regular lens of equal focal length. This will become even more apparent when the 35mm negative is enlarged to 8 x 10 or larger. However, for many types of situations the tele-extenders can provide the photographer with an inexpensive range of focal lengths to work with that can result in more than adequate results if properly used. The use of a tele-extender demonstrates yet another advantage of TTL metering because the addition of the extender will not require any exposure compensation since the meter actually measures only the light passing through the lens and any elements attached to it. If your camera lacks the TTL metering system, then it will be necessary to find a table that lists the exposure increases for extended lenses to use as a guide to determine the amount of exposure increase required with your extended lens.

The zoom lenses are very popular with cinematographers and have recently found some application by photographers interested in still photography with small cameras. The relatively wide range of zoom lenses on the market today provide a variable range of focal lengths with the use of a single lens. A zoom lens has an infinite selection of focal-lengths over a limited range (e.g. 35 to 85mm, 70 to 210mm, 210 to 300mm, etc.), which means you simply set the lens for the focal length that will produce the image size on the film that fits the situation at hand. Many recent improvements have made these lenses advantageous for many photographic situations, although they do produce some loss in image sharpness. How much of a problem this presents will depend upon the judgment of the photographer, and the degree of quality that is sought in the finished product. Other disadvantages are their relatively high cost, large size, and heavy weight in contrast to the better single-focal-length lenses. The zoom lens is extremely useful in taking pictures with color slide film since it permits the photographer to crop each slide exactly the way he or she wants in the view finder as the picture is being taken. This lens also offers an advantage when circumstances makes it necessary to carry only one lens for a particular job where several focal lengths would be very useful.

In order to produce a quality photograph, you must start with a clean, scratch-free lens. Fine photographic lenses are expensive and should be treated with a great deal of care and respect. In this connection it is important to note that optical glass is usually softer than regular glass and can be more easily scratched or damaged. Fingerprints and other greasy smears should be removed with a good quality lens-cleaning tissue. Cleaning may be aided by breathing on the lens to get a light coat of moisture that can be gently wiped off with lens cleaning tissue. However, lens cleaning fluids should only be used sparingly if at all, and if it becomes absolutely necessary to use a solvent, such as clean water or alcohol to remove a stubborn smear, then lightly moisten a wad of lens tissue, gently swab the lens, and then immediately wipe clean with another piece of clean

lens tissue. Never try to clean a lens with a dirty handkerchief or other woven material unless it is specifically manufactured for this purpose since cloth can pick up and retain particles of grit and/or dirt in the fibers that can badly scratch the surface of the lens. Dust should be removed by light brushing with a soft camel's hair brush or better blown off by a large rubber ear syringe or a blower made by inserting the glass tube from a medicine dropper into a three ounce rubber squeeze bulb (wrap a layer of tape around the tip for protection from glass to glass contact). This latter device is also very valuable for removing dust from inside your camera body and for blowing dust off of negatives to be enlarged or color slides to be projected. Also available on the market are special cans of clean, dry inert gas that will provide many strong bursts of air to blast away dust, but the syringe idea is far cheaper, essentially just as effective, and doesn't run out of air just when you need it most.

Sometimes the dust found on a lens is on an inside surface where cleaning is difficult, and the temptation becomes great to take the lens apart for cleaning. However, lenses should never be taken apart by the novice, but rather this job should be left to the trained technician.

In addition to scratching, chipping, or dulling a lens can also be damaged by the elements becoming out of alignment. This can occur by such things as a sharp jolt, dropping, or taking the lens apart and not reassembling it properly. To avoid the dropping or jolting of an expensive, high quality lens it should always be carried in a special padded case when not actually attached to the camera body. Many photographers prefer to keep all of their spare lenses and other accessories in a special case that has been made using a small suitcase or brief case outfitted with a foam rubber or styrofoam interior that has custom fitted areas removed to house the extra items for maximum protection and convenience in carrying. It is also important to keep a lens cap on both the front and back elements of a lens to prevent scratching, dust, and moisture on the lens surface while being stored. Except for the times when you are actually taking pictures, a lens cap should be kept on the front element of the lens mounted on the camera body.

How does one go about determining the quality of a particular lens that you are interested in purchasing or already own? Reading about the lens in question in a photography magazine before purchasing will at least give you some idea of the general quality of the brand you are contemplating. When you already have the lens and want to test it for quality, then some type of lens testing kit is in order. One example of a relatively inexpensive lens testing kit available is a series of charts and instruction booklet that can be purchased from Modern Photography Service, (2160 Patterson Street, Cincinnati, Ohio 45214) for approximately $4.95. In addition to general lens performance, the booklet also explains how to test your lens for color correction, alignment and curvature of field. The general principles behind this lens testing kit can be found in the December, 1970 issue of Modern Photography (pages 131-132).

CHAPTER V
CLOSE-UP PHOTOGRAPHY AND PHOTOMACROGRAPHY

Most 35mm cameras can focus on subjects as close as two or three feet without any special photographic accessories. Close-up photography is designed primarily to get the camera closer to the subject in order to increase its size on the film frame over that obtainable with normal photographic procedures, while photomacrography is designed to magnify the subject in order to increase its size on the film frame. Although these are not hard and fast designations, they are useful in describing the basic techniques and equipment involved.

The human eye cannot resolve objects that are closer together than 0.2mm, and does not see anything clearly at distances closer than approximately eight inches. The techniques of close-up photography, photomacrography, and photomicrography all enable the photographer to show important aspects of the subject in greater clarity and with much more detail than they would appear in nature to the naked eye.

If the image produced on the film is smaller than the subject being photographed, the scale will be a reduction and would be written as 1:10 (image:subject) or 1/10 when the subject is ten times larger than the image produced on the film. If the image produced on the film is larger than the subject, then the image:subject ratio might be written 10:1 (10/1) when the image size is increased ten times over the actual subject size. In general, close-up photography is considered by many to cover the range from 1:10 to 1:1 (image size equals the subject size) while the range from 1.1 to 10:1 is considered to be photomacrography. Beyond the 10:1 magnification, one gets into situations requiring the optics of a microscope to produce an enlarged subject that can be photographed.

In order to produce an increased image size, one either needs to get the camera lens closer to the subject or extend the lens-to-image distance beyond the normal for the particular focal length being used. The former can be accomplished by using close-up lenses attached to the front of your regular lens while the latter involves inserting an extension tube(s) or a bellows outfit between your regular lens and the camera body. It is also possible to purchase special macro lenses that can serve as a versatile way to take close-up exposures. It will focus much closer than an ordinary lens of the same focal length without any accessory equipment, but it also can be used at normal distances which allows for a rapid shift from normal to close-up photographs without a great deal of trouble. Both the bellows and the extension tubes (usually obtained in sets of three or four rings of different lengths) move the lens further from the film plane which enlarges the image on the film. This process is somewhat like moving a slide projector further from the screen in order to increase the size of the image on the screen. The bellows are more flexible than the extension tubes since the bellows usually has higher magnification capabilities and can be set at virtually any length within the range of the bellows. On the other hand extension tubes have only several increments of length

available, depending on the combinations that can be made by adding or subtracting sections. If you have an SLR camera be certain that the extension device you purchase has an automatic diaphragm feature and meter coupling so that you will not have to manually open the diaphragm for viewing and then close it down again for each exposure.

Since both of these extension systems decreases the amount of light that reaches the film, one has to compensate by using a slower shutter speed or a larger lens opening (smaller f-number). The longer the extension the higher will be the image magnification and the greater will be the required exposure since light diminishes in direct proportion to the square of the distance traveled. Doubling the effective focal length of your lens means the light will be traveling twice as far as normal, and its intensity will be reduced by a factor of four. With any extension of the lens you will find that the depth-of-field is rather shallow, and in order to get the maximum detail in each photograph, it is necessary to use the smallest lens aperture (highest f-numbers) that the lighting conditions will permit. The problem of decreased light must be solved by using a faster rated film (high ASA number) and/or longer exposure times. When sufficient light is a real problem, it is possible to expose some films at a film rating that is higher than their normal ASA rating in order to use a faster shutter speed or smaller lens aperture opening. The film is then force developed in order to obtain a negative of fairly acceptable quality (see page 10). The built-in exposure meter will make the exposure compensation for the lens extension relatively easy, but without this feature one will have to consult various tables in order to determine the exposure increase necessary with the increased lens extension.

The advantages of through-the-lens viewing found in the SLR camera are again very apparent with extension devices since one sees exactly what the film "sees" and also permits one to crop the subject area in order to include exactly what one desires on the film frame. The direct optical viewfinder found in some types of cameras produces a phenomenon called parallax in which the viewfinder doesn't show exactly what will be in the photograph.

When using extension devices at an image:subject magnification of less than 1:1 there is very little loss of performance compared with the use of supplementary lenses. However, when using a system that magnifies more than 1:1, it is sometimes advisable to reverse the lens by means of an adaptor to get results that are very sharp. Since reversing the lens also increases the magnification of the subject, this procedure can be used with or without an extension device to produce subject magnification as well as sharper pictures (See Figure 5). Having the rear element of the lens pointing towards the subject sounds as well as looks very strange, but optically it has been proven that a normal lens is sharper using this procedure. This system is excellent for extreme close-up photography, but does have the major draw backs of a very short range of subject to lens distance and the automatic diaphragm must be controlled manually. Before purchasing a lens reverse adapter be certain that you check on the size that will fit your particular camera.

Usually supplementary close-up lenses are the simplest and cheapest solution to the world of small subjects. They are especially useful for

full or nearly full frame shots of small items such as stamps, coins, pictures, etc. that are to be copied or to show the intricate detail in relatively small items such as flowers, insects, small plants, or a portion of a petri-dish to demonstrate some unusual bacteria colonies. The close-up lenses are positive elements that usually come in sets of three different sizes and screw into the front of your camera lens like regular filters. They are available in several different powers designated by the term diopter (e.g. 1+, 2+, and 3+). A lens of 1 diopter (1+) attached to a normal camera lens (any focal length) and set at infinity will be in focus on an object 1 meter from the lens. It is then possible to focus the lens on objects closer than 1 meter down to the limits of the system. A 3 diopter lens under the above conditions would have the subject in focus at 1/3 meter when set at infinity (note that the diopter strength is divided into 1 meter in order to get the focus distance at infinity). It is also possible to use the close-up lenses in combination to get even closer to the subject, but never use more than two lenses at a time or you may affect the sharpness of the finished product. It is also important to always place the highest diopter element next to the camera lens in order to get sharp, distortion free pictures.

The use of close-up lenses does not require any compensation in exposure, but the advantage of an SLR camera even with this attachment is again obvious. It permits the photographer to precisely view exactly what is going to be photographed and to crop the field exactly as desired or as the circumstances permit.

When using bellows or extension tubes it is almost imperative to use a camera with through-the-lens viewing because the problems of exposure and framing the subject are very complicated with other types of cameras due to the extremely close range of operation. When using these extension devices one should use lenses of average focal length in order to take advantage of the available bellows extension since long focus lenses cannot be focused before the extension is used up. Extension tubes, bellows, and supplementary lenses can be used in combination for extreme magnification, but the image quality is likely to suffer considerably.

In order to get sharp, clean images with extension devices it is important to have a firm, steady camera and as much depth-of-field as possible. The former is best controlled by using a good quality, sturdy tripod or a copy stand (See Figures 3 and 5). In many cases a fast shutter speed in bright light might compensate for some of the problems when it is necessary to hand-hold the camera. It is also possible to use a gun stock which is simply a modified gun stock with a camera platform designed to accommodate heavy camera equipment to provide a firm hand-held support. Another good method for holding a camera and bulky accessories steady for extreme close-ups or long exposures is the use of small, soft cloth bags filled with fine sand or small beans which can be placed on a solid surface and molded to custom fit the camera. This will hold the camera in a steady position very close to the subject to be photographed, and it can be easily moved from location to location or changed in position. Several bags can be used in combination to raise or lower the camera as well as to sandwich the camera between two bags for strong support.

With any of the above devices used to hold the camera steady, it is imperative to utilize a cable release or the camera self-timer as an aid to help avoid camera movement.

In close-up work it is sometimes difficult to obtain sharp, clear photographs of small objects because they are often a problem to pose, subject movement or camera movement is not easy to avoid, and they often require long exposure times. In order to circumvent these problems a subject mount that physically attaches to the camera has been devised so that when the camera moves the subject moves with it and vice versa. The mount has a kurled top locking collar on the base that attaches it to the bottom of the camera. It basically consists of a base with a moveable rod passing through it (held in place by a thumbscrew) that will permit the photographer to move the subject closer to or further away from the camera lens. A second moveable rod perpendicular to the first rod moves the subject up and down in order to center it in front of the lens, plus it has an alligator clip that is used to hold the subject in place. (For more details see: Modern Photography, March 1977, Page 80.)

Sometimes in trying to get a good photograph of a larger subject, it is difficult to keep the subject in sharp focus. This might be due to the fact that the subject is moving frequently (for example, an animal or a swaying flower) or because of a short depth of focus due to using a close-up attachment. Under these conditions a good sharp photograph can usually be obtained by mastering the following procedure: set the lens at one setting that has the subject in reasonably good focus, continue looking at the subject through the viewfinder, keep the subject in sharp focus at all times by moving the camera forward or backward with body movement (the movement should usually be from the waist up), and immediately depress the shutter release button when the subject is in sharp focus and ready to be photographed. A fast shutter speed is necessary to make the procedure successful.

If it is necessary to determine the f-number at which the lens is actually operating when using extension devices, it must be remembered that moving the lens away from the camera body produces an "effective" lens opening that will be different from the f-number engraved on the lens mount. When adding extension tubes or extending the bellows beyond the focal length of the lens being used, the subject area projected on to the film is greatly increased which spreads the available light much thinner. This in turn causes a reduction in the effective lens aperture. The instructions provided with the extension equipment should give information on how to calculate the necessary compensation.

As already indicated, one of the principal problems in photographing subjects at close range is subject movement. Such movement can be tremendously magnified in close-up photography, and it will produce a blurred image when exposing at slow shutter speeds. Subject movement can be a major problem when doing close-up or photomacrography work outdoors or when photographing living materials indoors. If it is not possible to take your subject indoors to photograph in an artificial set-up (which will solve many problems), then you will have to battle the challenge of wind and other adversities. However, the beauty and advantages of natural light may make the challenge more than worth the effort. One way to solve the problem of movement is to use fast shutter speeds to stop the action,

but with the lighting difficulties imposed by the long focal lengths and/or depth-of-field requirements, this is not always a viable option unless one wants to resort to push-processing of film to increase its speed. Other ways to solve the problem of movement include such things as supporting a plant with hidden wires, tying a branch back to the plant or to the ground, and setting up a simple windbreak made from a sheet of heavy, white cardboard, or a piece of plastic or heavy cloth.

Some photographers prefer to take nature indoors whenever possible to decrease movement by wind. However, pictures of animal subjects such as insects still present difficult problems. Some prefer to kill the insects and dry them attached to a natural object such as a small tree branch or in some other natural pose. It is also possible to put the insects in a refrigerator or freezer just before using them in order to slow down their metabolism and hence their activity. Some prefer instead to chase the insect (or other animal) until it is tired out and thus slowed down sufficiently for being photographed. It is also possible to prepare a set-up scene for the active subject that represents its natural habitat, prefocus on the area of the scene where you want the subject located, introduce the subject to the set, and quickly photograph. These are only a few examples of the many possibilities available to the imaginative mind, but they should at least provide some ideas that can serve as a basis to solve the problems that you might encounter in your photography work.

A vertical set-up or copy stand can be very useful for indoor pictures of small objects. The height of the camera is easily adjusted on the copy stand, and the plane of the film can be kept parallel to the copy stand in order to maintain a flat field across the entire film frame. With the appropriate lens attached to a bellows and/or extension tubes mounted on the camera body, it is possible to produce color slides of very small objects and even sections of microscope slides that can be used in the laboratory as a teaching aid. The slide can be placed several inches above a white or appropriately colored card, evenly lighted with several flood lights, and photographed. This set-up is also very useful for taking color slides of pictures from publications to use in the classroom as a useful and effective teaching tool. For this latter purpose use a good 35mm camera with a normal focal length lens and a set of close-up lenses.

When using flood lights with certain types of color films for any of the above, be certain that you either use the proper film or use the proper filter to balance the film type with the light source being used. Another important point to remember is that when you have flood lights on both sides of the copy stand, it can be hard to get an accurate meter reading due to the intense glare. Use a rubber eye cup or cup your hands around the view finder in order to shield from the stray light and obtain a more accurate meter reading.

A great variety of useful clamps for holding lights, flash units, reflectors, cameras, subjects to be photographed, etc. can be easily made for use in close-up work. Spring clamps come in a wide variety of shapes and sizes and can be purchased at most hardware stores. A variety of attachments can also be soldered to the clamps to increase their usefulness. For example, a small pipe or piece of slender metal rod can be attached to one of the clamp handles and used to secure the clamp in the ground or attached to a table with the appropriate hook-up. The clamp

end is then free to accept anything that needs to be held in a special position while a photograph is being taken. Other useful attachments are a ball and socket head, or a nut that will screw onto a tripod to produce a variety of clamp types that can be attached to a number of places for special uses (see Petersen's Photographic Magazine, April, 1978, page 61-62 for more ideas).

In close-up photography lighting is very critical and can make the difference between an acceptable photograph and one that is outstanding in quality and detail. For most work outdoors the use of natural sunlight on the subject is preferred, but when the situation involves very dim light or extremely heavy shadows, a flash unit can be very effective as a fill-in light. If you are confronted with medium dark shadows that you wish to lighten for more detail or even possibly eliminate, then try using a reflector made from a piece of stiff material coated with a glossy white paint, or use slightly crumpled aluminum foil mounted to a wood frame that can be stood or hung or simply mold the foil to stand by itself. A properly placed reflector can direct extra light to the areas of the scene where it is more needed.

For close-up work don't always be tied to the more traditional front lighting where the sunlight or other light source comes over the shoulder of the photographer and falls directly on the front of the subject to be photographed. If the subject has special texture, form, and/or other special quality that you wish to emphasize, try using backlighting or sidelighting in order to produce an interesting and creative photograph. These types of lighting create highlights and shadows that tend to produce a strong separation between the subject and its background to emphasize the shape and other qualities of the subject. For example, if the surface of the subject is finely textured, then place the main light at a low angle to accentuate the limited quality available. Backlighting is especially good for capturing the translucent quality of plants and other similar objects as well as creating stark and very dramatic effects with opaque objects. When using lighting coming from various directions, it is important to shield the camera lens from stray light in order to avoid lens flare. This can be accomplished by either using a lens hood attached to the prime lens or by shielding the lens with a cupped hand (be certain you don't photograph your hand). With any type of illumination be careful you do not create shadows of yourself or the equipment being used that will show up in the scene being photographed.

Since bright sunlight can be very harsh and produce a great deal of contrast, it is sometimes advisable to use a fill-in flash to help reduce the lighting contrast between the bright highlights and the shadow areas in the scene being photographed. When using daylight corrected color film, be certain to use a type of flash that is compatible with it (e.g. electronic flash or flash cubes) in order to have consistent color quality. The most versatile and useful type of flash for close-up work is one that has an extension cord so that it can be positioned in a variety of angles and locations away from the camera body. The proper lens opening for use with a flash unit can be determined by consulting the exposure table that came with the unit and determing your depth-of-field requirements. With extreme close-ups an easy method for calculation is to set the lens at its smallest opening and divide the guide number for the flash unit by the effective lens opening number to determine the flash-to-subject

distance needed for proper exposure. If the distance is not at handy arms length or if you need the use of both hands for taking the photograph, the flash unit can be mounted on a ring stand or other solid object using a large clamp and positioned at the proper distance and desired angle. The sand or bean bag method for steadying a camera that was discussed earlier can also be put to good use in positioning the flash unit.

In some situations one might be photographing a subject that is very dark or very light and located on a background of contrasting shade. The photographer might be very interested in trying to retain the original tone of the main subject. In order to do this take a reading from the subject that will produce results that are lighter and darker respectively. However, a better way to get a proper exposure that will retain the original tonal distinctions is to substitute a photographic gray card (a special card of known reflectance used to determine exposure) for the subject, take a meter reading in the usual way, and expose the film. The gray card will insure a proper exposure of the scene, and yet retain the tonal qualities of the various components found in the scene being photographed.

Some situations in close-up or photomacrography require a very soft and diffuse light source that evenly illuminates the subject. This can be easily accomplished by using a translucent, cylindrical tube of the appropriate size that is placed around the subject and illuminated with photoflood lights. Some photographers simply use a white lamp shade bathed in light from several high-intensity lamps for this purpose.

When photographing small objects it is sometimes desirable to physically separate the subject and background which will improve the technical presentation and eliminate shadows. This can be accomplished by using an elevated clear shelf of glass or plastic with the lights positioned to prevent any reflection off of the shelf itself. Using a well placed reflector on the shelf can help lighten the shadow areas of an irregularly shaped subject in order to get improved detail.

Taking pictures of whole organisms or parts of organisms that have been freshly preserved or that have been stored in fluid for some time presents few problems if the specimen is photographed under fluid. This procedure will remove undesirable highlights and accentuate certain features. All that one needs are a copy stand or sturdy tripod for holding the camera and the appropriate accessories plus illumination with two photoflood lamps housed in 8 to 10 inch reflectors preferably fitted with clamp on diffusion screens and controlled by a rheostat. The specimen(s) to be photographed should be rinsed in distilled water, and then submerged in a clean container of physiological saline solution. Glass or plastic rods can be judiciously used as a means of supporting and/or positioning the specimen. Be sure to remove bubbles and other possible artifacts that might be distracting in the photograph. If the specimen will not stay submerged in the saline, then it may be necessary to pin lead weights to the underside before placing it in the fluid. (See Preparation and Use of Frog Dissection Slides Activity in the Appendix.)

When taking pictures of very small objects it is always important to have a record of size. This can be magnification data (determined from the camera lens and print enlargement) that is recorded with the final

print or it can be visually accomplished by photographing an inch or centimeter rule along with the specimen. With a very thick specimen it may be necessary to support the rule with glass or plastic rods in order to get it at a level where it will be in sharp focus with the specimen (see Figure 5a inside back cover).

When photographing a specimen such as an animal dissection that is intended for a visual aid in the classroom, small pieces of light cardboard cut with a point at one end and pinned into the specimen will help to identify the specific parts. An even more useful slide will have the name of the specific part printed on the cardboard piece in order to make a slide that can also be used for a student self-study program. In making such projection slides it is possible to use either color reversal film and obtain regular 2 x 2 color slides, or it is also possible to take the pictures with Kodak panatomic-X, 35mm film and make black and white projection slides. This latter technique requires a Direct Positive Developing kit plus the usual film developing equipment. The procedure produces beautiful black and white slides that are ready for mounting in either cardboard or plastic mounts.

CHAPTER VI
PHOTOMICROGRAPHY

In photomicrography a regular compound microscope (or dissecting microscope) is used to magnify a very small subject so that it can be photographed with a camera (See Figures 4 and 6). In photomicrography the lens is removed from the camera, and the camera body (back) is placed over the microscope ocular (eyepiece) with a light-tight coupling. The complete optical system of the microscope is used to project the image normally seen with the eye onto the film in the camera back. Even a very simple student microscope can be used for this purpose, but it must be realized that the final product can only be as good as the microscope optics used to make the photograph. It doesn't take an expensive camera back to make excellent photomicrographs, but a fine set of microscope optics and a good lighting system properly focused on the microscope field are the chief requirements. Seldom is the image recorded on the negative of better quality than the image produced by the microscope, which makes it imperative that one learns the proper way to use a microscope in order to get the best possible image from the subject being used. The magnification of the subject on the film is dependent on the magnifying power of both the objective and ocular and the distance of the camera's film plane from the ocular. Most laboratory compound microscopes are capable of magnifying the subject from approximately 50X upwards to 1000X or higher, depending on the combinations of objectives and oculars used. A discussion of the fine points of microscope optics, the proper procedures for setting up a good microscope, and properly adjusting the lighting system are beyond the scope of this publication. There are a number of excellent books and pamphlets on photomicrography, plus the very useful manual that usually comes with a good laboratory microscope, that can be consulted for this type of information (e.g. Photography Through the Microscope, Kodak Publication, P-2). However, even in this type of publication it should be heavily stressed that it is absolutely critical for the illumination to be correctly focused and centered in order to prevent "hot spots" in the photograph. Also the optics of the microscope must be kept meticulously free of dust and smears since any dirty areas will also be magnified and appear in the photograph. The earlier section on tips for cleaning the camera lens can also apply equally well to the optics found on a microscope.

The Polaroid Corporation has a variety of camera outfits available that utilize the special and useful Polaroid films. Several Polaroid camera models with different film sizes have been developed for use with the microscope. An inexpensive, but very functional, microscope camera for general use is the Model ED-10, which provides relatively sharp and crisp photographs (See Figure 6a). Polaroid film is a self-contained unit that can be exposed and immediately developed to produce a permanent print in one minute or less (depending on the film type). Some of the advantages of Polaroid film include virtually instant photographs to use for on-the-spot student demonstrations, eliminating the need for a darkroom facility, and can be successfully used by a student who hasn't had any

previous photographic experience. Polaroid films are available in both color and B & W, several different ASA ratings, a variety of film sizes, and different types. The latter includes films that provide a print plus a good quality film negative, and even a film that produces a slide for projection.

Generally standard lighting should be used for all photomicrography work. When using color film be certain that the film type is corrected for the light source being used or use the appropriate correction filter. Some light sources have a special holder for filters, while in other situations you may have to construct a homemade device that will place the filter in the light path of the microscope. Neutral density filters can be used to decrease the light intensity without affecting the color balance. Always be aware that changing light intensity with any rheostat type mechanism will affect the color balance so remember to check the manual for the light source to learn its color temperature at different settings. Color filters can also be used to highlight different aspects of the subject by darkening or lightening colors for specific results in black and white photography. If a part of the subject that you wish to highlight is colored light blue and surrounded by an area that is red, then a red filter would lighten the background and darken the blue color on the final print to provide maximum contrast. On the other hand a blue filter would lighten the blue area on the final print.

To insure the best photograph of a particular subject, it is always a good idea to bracket the exposure that has been determined with the metering system. In other words use the exposure determined with the meter, then take a second shot giving more exposure, and a third shot with less exposure. Since the camera-microscope set up lacks the use of a lens aperture system (f-number) for bracketing exposure, one must resort to using a time increment on either side of the normal exposure time that has been determined. In order to calculate exposure increases in time instead of f-stops, multiply the original exposure by the following factors:

f-stop increase	multiply exposure by this factor
1/3	1.3
2/3	1.6
1	2.0
1 1/3	2.6
1 2/3	3.3
2	4.0

The objective lens of the microscope produces the primary image that is further magnified by the ocular. The quality of the objective lens has a great deal to do with the quality of the photograph, and investment in a high quality objective can be very worthwhile for the serious photographer. Most objectives have some "curvature of field" which provides a sharp image in the center of the microscope field with the sharpness falling off toward the periphery. This problem can be solved to some extent by limiting the area to be photographed to the center part of the field or by purchasing special objectives that are claimed to be "flat-field"

objectives. Special oculars are also available for photomicrography, although regular "Huygenian" and "wide field" oculars are very satisfactory for low- and medium-power objectives. However, better results can be obtained with "Hyperplane" oculars for B & W photography and special "photo eyepieces" for color photography since they tend to produce reasonably flat fields along with other corrections.

The problem of focusing the microscope image onto the film plane in order to obtain a sharp, high-resolution negative is an important consideration when setting up to do photomicrography. Camera equipment designed for photomicrography usually has a specific procedure for adjusting the apparatus for a sharp focus. If you do not have a special procedure outlined for your particular set up, then a satisfactory method is as follows: (a) get a good, high-contrast microscope slide into sharp focus under the microscope; (b) open the camera back and place a piece of ground glass (circa 1.5mm thick) where the film plane would be; (c) adjust the camera back up or down until the image is in sharp focus on the ground glass; and (d) remove the ground glass, load the camera with film, and start shooting pictures.

A waist-level or right angle view finder is a good accessory for use with a copy stand, a microscope setup, or other situation where the camera is in a vertical position (See Figure 3b). This permits easier viewing of the image produced by the microscope since the location of the camera on top of the microscope often makes it difficult to get your eyes at a level high enough to look down into the camera viewfinder with any degree of comfort. However, this accessory viewfinder does require more light for good viewing which is often a distinct disadvantage in photomicrography.

Vibration of the microscope-camera setup can be a real problem in photomicrography. The basic reason for this is the fact that the setup is often very tall and top heavy which only accentuates any table movement or movement caused by the shutter mechanism. The vibration problem can be decreased by such things as using a very sturdy table for the apparatus, obtaining short exposure times by using fast film types and/or high intensity lighting, the use of a good cable release, and securing the camera and other accessories to a sturdy tripod or ring stand.

In photography the recording and filing of data gathered for the photographs that have been taken is extremely important. It not only provides the photographer with base line information to help improve his/her future technique, but it also serves as a reference when using the photographic materials for publication, demonstration, exhibition, etc. The following list of items represents the kinds of information that need to be recorded when taking photomicrographs:

(a) Specimen details (scientific name, how processed, staining, etc.)
(b) Type and intensity of light source
(c) Filters used
(d) Exposure time
(e) Film type and details of development
(f) Objective lens used and total magnification of system

This type of data kept on file can be useful because referring to such data can save both time and film. It is also useful and important to keep

exposure data on the back of each photograph, but be careful never to write directly on the back of a print since this will usually leave an imprint in the paper that will damage the emulsion and show through the front. It is possible to either write along the boarder area on the front or back of an unmounted print which won't spoil the picture area, or one can write the necessary data on a paper label and attach it to the back of the print. If the print is attached to heavy mounting board, then the data can be written on the back of the board without any problems.

When photographing material mounted on microscope slides, it is useful and important to prepare record sheets for recording pertinent data. It is most useful to prepare a standard form that can be inexpensively duplicated by mimeograph or spirit duplicator. The following is an example of such a record sheet that has proven efficient and useful:

Name _____ Date _____ Film _____

Film Developer _____ Time & Temperature _____

FRAME	SUBJECT	SLIDE NO. & LOCATION	TYPE OF SCOPE	EXPOSURE TIME	LIGHT & FILTER	COMMENTS
1.						
2.						
3.						
etc.						

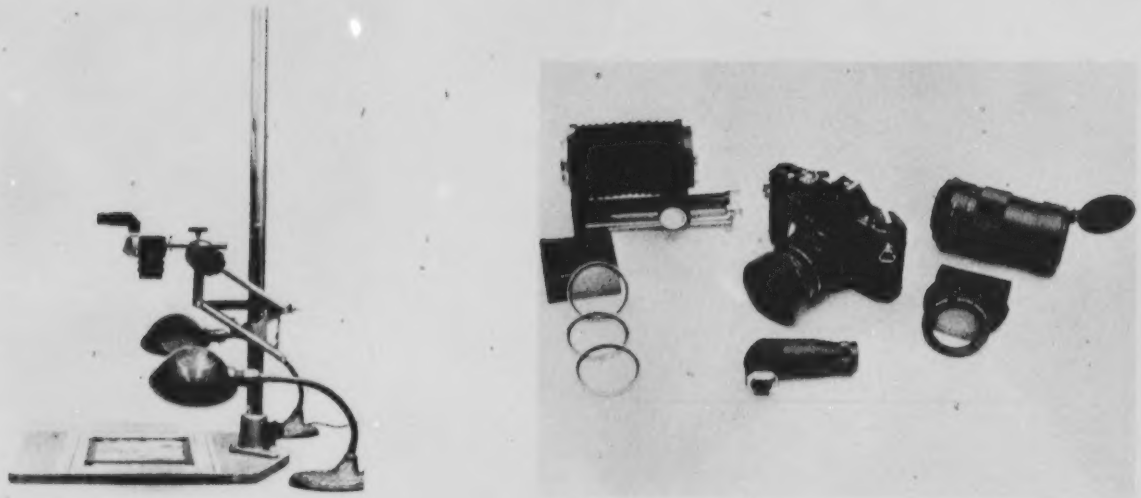
In photomicrography the following factors control the final magnification of the image on the negative:

(a) magnification power of the objective
(b) magnification power of the ocular (objective)
(c) whether or not the ocular is used
(d) use and length of extension devices such as a bellows

The image is first magnified when focused on the negative by the microscopes optical system, and then it is magnified again when the negative is enlarged to produce the print. It is necessary to determine the exact magnification of each specific set up that uses different combinations of the above listed factors. The magnification of the image on the negative with a specific combination of factors can best be determined by putting a micrometer scale on the microscope stage, and getting it in sharp focus like any other ordinary slide. A stage micrometer is a miniature metric ruler that generally has a 1 or 2 millimeter scale etched into the glass slide and divided into 0.1mm increments. This scale is then projected onto the film or a ground glass screen where it can then be photographed and measured on the negative or print produced from it or measured directly on the ground glass. Using either method the magnification can be calibrated by comparing the magnified scale that is produced with a normal centimeter scale. For example, suppose that 0.20mm on the magnified scale actually measures 50mm on the normal centimeter scale. This actually

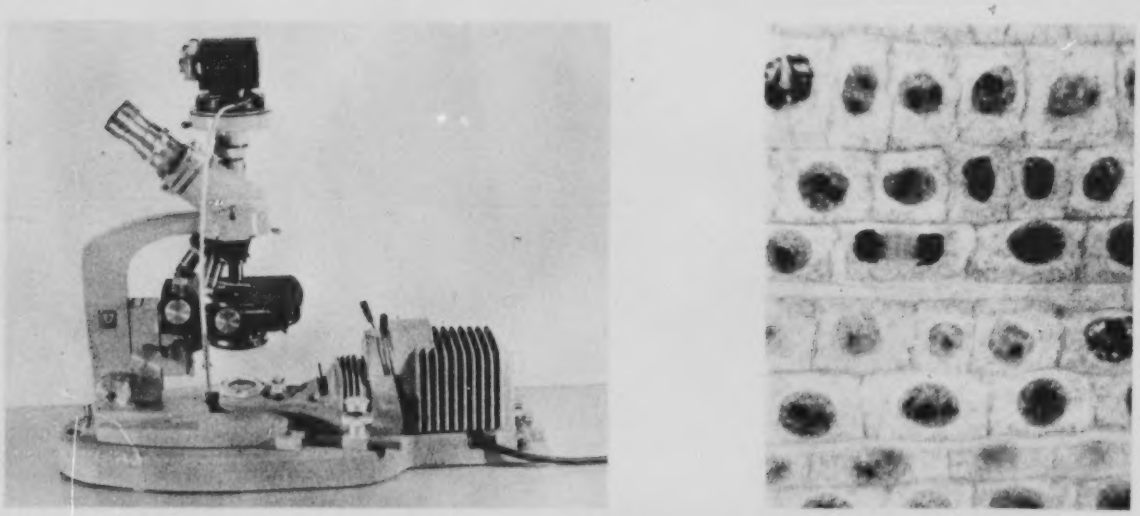
means that the 0.20mm has been magnified by a factor of 250 times (50 ÷ 0.20). This type of calibration factor for a particular optical system is most often written as 250X. If this is done for each of the most frequently used combinations of optical powers and accessory equipment, then this data can be recorded and used for all future negatives produced at the various combinations of factors calibrated.

When determining how much a particular negative has been magnified during enlargement to make a print, simply leave the enlarger set at the height used to make the enlarged print, put a clear plastic ruler in the negative carrier, and then use another ruler to measure the magnified scale projected onto the enlarging easel. Use the same procedure as above to calculate the magnification. If it is frequently necessary to know the magnification of the enlarged prints produced, it might save a great deal of time to calculate the magnification produced with the lens at a variety of distances from the easel and mark these locations on the columns or girders supporting the enlarging head. A quick check at which mark the head is located for a particular enlargement, will immediately provide information on the magnification of the print being produced.



A B

Figure 3: Accessories for close-up photography and copying work: (a) A 35mm camera mounted on a copy stand - the photographs of the Cecropia moth (Figure 1) were taken with this setup using a 55mm camera lens supplemented with a close-up lens. (b) A typical 35mm camera surrounded by some useful close-up accessories. On the left side of the camera is a set of close-up lenses and a bellows attachment. On the right side is a telephoto lens and a macro adapter. Below the camera is a right angle view finder (see page 31).



A B

Figure 4: Typical setup for photomicrography: (a) Compound microscope and an AO Ortho-illuminator outfitted with a 35mm camera for taking photomicrographs of very small objects. (b) Photomicrograph of onion root-tip mitosis taken with the equipment pictured in (a).

CHAPTER VIII
THE DARKROOM

Any discussion of photography should include a section on the darkroom, even though it will not be possible to cover the topic with any degree of completeness. One of the biggest thrills in photography is to display a finished print that has resulted from an evening spent in the darkroom. The photographer has a variety of techniques available to transform a plain negative into a positive print which portrays the detail, mood, creativity, etc. that the photographer desires to express. This manual will only attempt to provide a basic introduction to darkroom procedures. The more serious and competent photographers can consult the references listed elsewhere in this manual to find excellent discussions on a variety of advanced photographic techniques and procedures.

This manual will concentrate on the processing of black and white films and paper only. The argument of whether it is better to use color or black and white film is purely academic since each has its own unique advantages for specific situations and affects. If you desire to process your own color films, it is possible to purchase special color processing kits. There are also excellent kits for making your own color prints from either color slides or negatives in your black and white darkroom. However, it is advisable to develop good skills in the black and white darkroom before attempting to do your own color printing since the latter work requires not only the basic skills of printing, but also the development of an "eye" or sense for color balance.

In order to obtain a high quality enlarged print one needs to start with a clean, blemish free negative of correct density and proper contrast. Most serious photographers prefer to develop and print their own black and white film because of the superior quality that is obtainable due to the fine control one has over the entire process. However, it is important to remember that in order to obtain consistent and high quality results in processing photographic materials, never let yourself be rushed or perform any of the steps carelessly. Some of the photographic procedures can become very routine, and it is imperative that one thinks through each procedure and perform that procedure with great care and patience. It is also important that everything in the darkroom (including your negatives) be kept scrupulously clean at all times. Frequent cleaning of the darkroom and your equipment (especially the lenses) will pay very handsome dividends in defect free negatives and prints. An extremely important "golden rule" to establish in all your photographic operations is to develop standard and consistent procedures for the various steps. Develop a reasonable system that works well for your particular situation and stick to it.

The basic materials and steps involved in developing black and white film include the following:

2. Use one negative and a small piece of photographic paper to make a test strip in order to determine the proper exposure. It will probably be somewhere around 1 to 3 seconds depending on how high the enlarger lens is from the contact printer, and how far the lens is stopped down. By standardizing the procedure a great deal of time can be saved when making future proof sheets.

3. The negatives are positioned over a piece of 8 x 10 photographic paper with the emulsion side (dull surface of the negative) facing down against the emulsion side (shiny surface) of the paper - this can be done under the safelight.

4. Give the proper exposure and develop the paper.

One problem is that the exposure will be for one negative density, and in a typical roll of film you will usually have several different densities represented. The best exposure then will have to be one that provides the proper exposure for the maximum number of negatives.

Each proof sheet is a permanent record of the negatives that you want to keep, and it can be used to decide which negatives should be printed, and how each one used should be cropped to give the best results. There are many ways to file and store the proof sheets, and each has its own specific advantages and disadvantages. Two examples will serve to provide you with some ideas that you can use or modify: (a) The proof sheet can be punched with three holes and filed along with the plastic negative file carrying the negatives into a three-ring binder. One can use three-hole dividers with tabs to segregate groups of negative files and their proof sheets on the basis of subject matter, date of exposure, etc. (b) The glassine envelopes or plastic strips can be stored in a large envelop, the necessary data can be recorded on the outside, and then attached to the back side of the proof sheet with glue or tape. The proof sheet can be punched with holes and filed in a three-ring binder or simply stored in empty 8 x 10 enlarging paper boxes with some identifying data taped to the end of each box.

CHAPTER VII
PROOF SHEETS AND STORING NEGATIVES

Anyone who really gets involved in 35mm photography will soon accumulate a large number of 35mm color or black and white negatives. In order to get the best quality prints from your negatives, they should always be carefully stored in a location free from dust that will also prevent finger prints when handling and damage to the delicate emulsion. No matter how they are stored, the following information needs to somehow be included with the negatives: date the film was exposed, subject information, film type, type and length of development, lens used, filters and special effects, and lighting used.

One storage system involves the use of glassine envelopes or strips of plastic negative preserver that houses strips of five or six frames. They can then be referenced and stored in special sized filing boxes or large sized envelopes. There are also a number of different types and styles of plastic negative files on the market that accept a 36 exposure roll of 35mm film, and are designed to fit over an 8 x 10 piece of enlarging paper when making a proof sheet. This type of negative file is intended to fit into a three-ring binder for permanent storage.

A proof sheet is a composite print that represents all of the frames on a given roll of film. Each negative is, therefore, a contact print of itself the size of a regular 35mm frame all printed on a single sheet of enlarging paper. The proof sheet will provide the photographer with a quick look at the contents of a complete roll of film, and also provides a visible aid for selecting specific frames for enlarging. Although separate proof sheets can be made for each strip of five or six negatives, most prefer to make an 8 x 10 proof sheet for each 36 exposure roll of film. One can purchase a contact proof printer that holds the negatives in place over an 8 x 10 piece of photographic paper. The contact proof printer basically consists of a metal or plastic base that has a hinged piece of glass with some type of device for holding the strips of negatives in place over the photographic paper. A cheap substitute is to simply place the negatives over the paper directly under the enlarger and press them together with a piece of clean glass. One advantage of the plastic negative file is that it can be set directly over an 8 x 10 piece of paper, covered with a piece of clean glass, and exposed.

One method for making a contact proof sheet from black and white negatives is as follows:

1. Put the negative carrier in the enlarger without any negative in it, position the contact proof printer (or a glass plate on an easel set to 8 x 10) under an enlarger that has been set so that it just illuminates the proof printer, stop down the lens about half way, and shut off the enlarger light.

STEPS

a. Preparation of the necessary chemicals
b. Loading the film in a developing tank
c. Development
d. Stop bath
e. Fixing bath (hypo)
f. Hypo clearing bath
g. Washing
h. Wetting agent
i. Drying
j. Storage

CHEMICALS

a. Developer - e.g. D-76 or Microdol-X
b. Stop bath
c. Fixer
d. Hypo clearing agent
e. Photo-flo

EQUIPMENT

a. Developing tank and reel
b. Bottle opener or film-cassette opener
c. Scissors
d. Thermometer
e. Container large enough to hold tank and extra water
f. Timer or clock with second hand
g. Film clips for drying

The proper preparation and storage of the photographic chemicals is very necessary to obtain quality results. Use only products produced by reputable manufacturers, and don't try to save a little money by using exhausted or nearly exhausted chemicals. The various chemicals should all be mixed with clean, particle free water according to the directions on the packages (some prefer to use distilled water for mixing chemicals), and stored in clean, dust free brown containers. If the local water supply contains significant amounts of particulate material, and you don't have access to distilled water, then it might be necessary to filter the water before use. Carefully note the information concerning the storage life for each chemical found on the package, and be certain to clearly date each newly prepared chemical. If the freshness of a chemical is questionable, then it is probably prudent to prepare a fresh batch. When chemicals are not used frequently, used by several different persons, or used to exhaustion, it might be thrifty as well as wise to use an indicator stop bath (which changes color when it becomes exhausted) and a Hypo-Chek to evaluate the fixer. This should avoid the problem of someone inadvertently using exhausted or nearly exhausted chemicals, which might end up ruining some valuable photographic materials. After using graduated measuring containers, funnels, thermometers, etc. for handling chemicals, be certain to rinse them very carefully in order to avoid any cross contamination of the chemical solutions.

When preparing to develop a black and white film carefully mix the developer according to directions from the stock solution, and adjust it to the proper temperature by submerging the container in either warm or cold water. The other chemicals should be measured out into the properly labeled receptacles and also adjusted to the correct temperature. The stop bath and fixer can be reused several times, and they should be stored in clean, airtight containers between uses.

The film to be developed must first be loaded onto the reel of a developing tank in the absence of light by using a dark bag or a light-tight darkroom. The tanks currently available on the market include a variety of plastic models with adjustable reels and the more traditional stainless steel models. Both types have their own advantages, but whichever type you choose, be sure to get a model with a lid that will permit rapid and

efficient filling and emptying. Before attempting to load any developing tank for the first time, try practicing the procedure with some used film by closing your eyes to simulate working in total darkness.

When loading film into the tank it is desirable to put the tank components, film cassette, bottle opener, and scissors in a shallow tray so that you can easily locate each item in the dark as needed. Load the film onto the reel very carefully since any contact between the film surfaces during development will result in undeveloped areas on the negative. Put the loaded film reel into the tank bottom and carefully put the cover in place. If you have put the lid on properly, then you can turn on the regular lights since the chemicals can be poured into the tank without exposing the film. The length of development and the temperature of the developer are very critical factors, and either one or both can dramatically change the quality of the results obtained. Contrasty, overdeveloped negatives will result from leaving the film in the developer too long and/or using a developer that is too warm. Flat, underdeveloped negatives result from taking the film out of the developer too soon and/or using a developer that is too cold. In order to maintain the temperature of the developer at the correct level, some photographers prefer to keep the tank approximately three-fourths submerged in a container of water adjusted to the same temperature as that desired for the developer. The developing time should start as soon as the developer enters the tank which is the reason for having a large and efficient pour spout on the tank in order to get the film covered quickly. In order to dislodge any air bubbles that might form on the surface of the film and produce spots on the developed negative, it is desirable to gently tap the tank on a solid surface. Agitating the film during development is an essential part of the developing procedure if one wishes to get consistently high quality results. Carefully follow the directions for agitating the film as recommended by the manufacturer of the developer. At the end of the developing period rapidly pour off the developer, quickly replace with the recommended stop bath (some prefer to use distilled water), and agitate continuously for the prescribed time. Replace the stop bath with the proper fixing solution and agitate frequently for the prescribed time. After pouring out the fixer, the tank cover can be removed and the film washed in running water for the length of time indicated on the film instruction sheet. Proper washing is extremely important to insure the permanency of the negative since even minute traces of chemicals left in the emulsion will cause discoloration and fading. A good washing procedure involves using a rubber hose that will extend to the bottom of the tank so that the entering water flows from the bottom, over the film, to the top of the tank. The water flow should be rapid enough to change the water in the tank several times a minute. It is a good idea to use Kodak Hypo-clearing agent in order to drastically shorten the wash time which can save considerable amounts of water. It is also highly desirable to have all of the chemicals including the wash water at the same temperature (or as close as possible) as used for the developer. After washing the film it should be treated with a wetting agent, such as Photo-flo, to prevent streaking. Attach a film clip to one end of the film and hang it in a dry, dust-free place. The other end of the film should also have a clip attached to it which will keep the film slightly taut while it is drying. After the film is dry, it should be cut in lengths of five or six frames and stored in glassine negative envelopes, vinyl pages, plastic sleeves, or other suitable dust free protectors. This procedure is very important to prevent fingerprints and scratches which can ruin an otherwise perfect negative.

Using a clean, dust-free negative which has the proper contrast and correct density, one can make either a contact print or an enlargement. A contact print is identical in size to the negative from which it was made, and in 35mm photography the small negative size makes this type of print relatively useless except for the preparation of a contact proof sheet for recording the content of an entire roll of film on a single 8 x 10 sheet of photographic paper. An enlargement is larger than the negative from which it is made, and is produced by projecting the negative with a lens system onto a fast bromide or medium-fast chloro-bromide enlarging paper. The process of enlarging requires an adjustable enlarging easel to hold the enlarging paper flat, a good enlarger with a heavy baseboard, and a high quality enlarging lens. When using a 35mm foremat, a 50mm enlarging lens will be the only lens needed.

Using a good contact proof sheet made from your negatives, choose the frame and the area of that frame you want to enlarge. Clean the negative carefully and put it in the negative carrier with the dull (emulsion) side of the negative down towards the enlarger lens. Dust and other defects can often be detected on the negative by putting it in the negative carrier, holding it at a sharp angle under the light from a wide open enlarger lens, and viewing it from several different angles. Cleaning the negative can be done with such items as a camel's hair brush, Kodak film cleaning fluid, aerosal cans of compressed air, the inexpensive blower described in an earlier chapter, or a staticmaster brush. However, keep in mind that the emulsion is fairly soft and easily damaged by chemicals and rough handling. A piece of plain white paper, the same thickness as the enlarging paper to be used (the back side of an unexposed piece of old enlarging paper works very well), is held in the easel and centered on the baseboard of the enlarger. The enlarger lens is opened to its brightest opening (the smallest f-number), the carrier inserted into the enlarger head, the enlarger lamp turned on, and the negative focused onto the white paper with the focus knob. Raising or lowering the enlarger head will increase or decrease the size of the enlargement, and permit the cropping that is desired. If only a portion of a negative is to be enlarged (cropping), the rest should be masked with black paper. This will avoid the problem of stray light fogging the sensitized paper and causing a grayish appearance in the highlights of the print. After final adjustments to get the sharpest focus, the lens is usually stopped down two or three f-stops in order to take advantage of the better portion of the lens and get the sharpest print. When deciding on an exposure time, remember that each decrease in f-stop will decrease the light intensity by one-half. Likewise each increase in f-stop will make the image twice as bright as the previous setting.

With only the safelight(s) turned on, remove a sheet of enlarging paper and cut it into strips about 1½ inches wide and about as long as the width of the enlargement you expect to make. The enlarging paper must always be handled only by the edges and only with clean, dry hands free of chemical residues. It is also important to keep the enlarging paper properly covered at all times to avoid accidental exposure. The small pieces of paper are called test strips, and one is placed on the easel in a position that corresponds to an important area of image that is of most interest. The object is to discover the combination of f-stop and time of exposure that will produce a print with areas that have the blackest black and whitest white the paper can produce along with some fine detail and

intermediate grays. If after development the test strip does not have the correct exposure, then the exposure can be corrected by either increasing the exposure time and/or opening up the lens to make the over-all print darker or decreasing the exposure time and/or stopping down the lens to make the over-all print lighter. Generally it is best to have the lens stopped down as indicated earlier, and an exposure time of 10 seconds or more in order to have time for dodging or other creative effects. The development time required to produce a satisfactory print or test strip depends on the exposure time and the temperature of the developer, but it shouldn't be less than one minute nor longer than 2½ minutes. After making a successful test strip you can then proceed to producing a full-sized print. Proper development of the exposed test strips and the full-sized print requires some practical but important considerations. The developer should be freshly prepared from a stock solution, and it should be discarded at the first sign of becoming exhausted. The developer temperature should be maintained somewhere between 68 and 75 degrees F. The exposed enlarging paper should be slid into the developer quickly and evenly, and then agitated by gently pushing around the print in the tray until the development is complete. If the paper is manipulated by print tongs, touch only the edges of the print, and be very careful not to scratch the emulsion. It is also important to have a set of tongs for each tray, being careful to avoid cross contamination of the trays by interchanging the tongs. Many photographers prefer to handle the print edges with the fingers instead of using tongs. This latter technique requires rinsing the hands after moving the prints from one solution tray to another. The print must be kept under the developing solution at all times, but don't permit your hands to remain on one area of the print very long or heat from the fingers will cause stains. If your skin should become sensitive to the chemicals, a pair of rubber surgical gloves provides a way to avoid this problem. No matter what techniques you use, your hands are going to get wet from being in liquids or washed free of chemicals. Therefore, it is desirable to have a clean towel on hand at all times for drying the hands.

After development is complete, the print is removed and allowed to drain over the developer tray for a few seconds, and then it is quickly slid into the stop bath for 30 seconds with constant agitation. Again the print is drained, and slid into the fixing bath where it is frequently agitated. Because the fixer bath gets contaminated with stop solution, it is recommended to use two fixer baths in sequence. The print can be soaked in the first bath for approximately two minutes with frequent agitation; drained briefly, and transferred to the second bath for three to eight minutes with agitation to give a total time in the fixer of five to ten minutes. The proper length of time in the fixer depends on its freshness. Do not over-fix the prints since this doesn't fix the print any better, and it may result in bleaching of the image or yellow staining with time. However, remember that too little time in the fixer (especially if it is well-used) will fail to adequately stabilize the emulsion for permanency. Don't try to economize on the fixer since the end result may be more costly than the few cents saved along the way. Don't turn on the white light to examine the results of your work until after the print has been in the fixer for at least two minutes. However, the constant turning on and off of the lights makes it very hard to keep one's eyes accustomed to seeing well under the safelight, and it is often desirable to avoid this problem by learning to "read" the print quality under the safelight. In any situation it must be remembered that a print always appears lighter

in the fixer or water than it will when dry, and that under the safelight a print appears darker than it will under the white light.

After fixation the print is drained and transferred to a deep wash tray (equipped with a tray-siphon) with running water where several prints can be gathered and later washed at one time. When determining the length of time a print has washed, the time is calculated when the last print is put in the wash water, since it will carry contamination from the last solution into the wash tray. Adequate washing is essential to print permanency since chemicals left in the emulsion and/or paper fibers will cause stains and fading with time. Remember that double-weight papers will require more washing time than single-weight papers. Also be careful not to overload the print washing bath or the prints may tend to stick together and result in inadequate washing. It is also important to occasionally agitate and rearrange the prints during the washing procedure to avoid prints sticking together and not getting properly washed. The amount of washing time can be greatly reduced by the use of hypo-clearing agent, but remember that the prints should also be frequently agitated during this prewash treatment.

The prints can be treated in a print flattening solution prior to drying in order to cut down on curling. The drying method will determine the emulsion finish on regular type papers. If the print is dried face up on the heated dryer or in a photo blotter roll, it will have a non-glossy matte finish. This type of finish makes the prints easier to retouch with dyes, and are less likely to crack if improperly handled. Some papers are designated "glossy" surface and can be used either to make a matte or glossy finish. A glossy finish can be obtained by rolling a dripping wet print firmly face down onto the shiny surface of a ferrotype plate with a roller or squeegee. It is critical that the entire print surface be in contact with the surface of the ferrotype plate without any air bubbles. Excessive moisture can be taken up with a large piece of blotter paper, and the prints dried thoroughly either at room temperature or in an electric dryer. Permit the prints to come up off of the surface of the ferrotype plate by themselves - do not try to pry them off prematurely or parts of the emulsion may stick to the plate and ruin the print. The ferrotype plate must be absolutely clean and free of scratches. The plate can be cleaned with a soft cloth under a stream of warm water, dried, and polished with a ferrotype plate polish. Some prefer to place the prints on the plate immediately after washing in the warm water. The glossy surface has a very bright and crisp appearance, and is the surface desired for prints that are to be reproduced for use in publications such as newspapers and magazines. The matte surface is more subtle, and provides a pleasing appearance for many types of photographs such as portraits and prints for display purposes. Each surface can add something special to a particular print, and it is the job of the photographer to choose the one which will do the best job of reproducing the subject matter or mood intended.

If you use an electric dryer, be patient and don't try to dry them too quickly by turning up the heat excessively. High heat will cause the prints to shrink unevenly, which will tend to make them warp. The best way to dry the prints is with a gentle and even heat. When the prints are removed from the drier, it helps to cut down on the curling if they are pressed for a brief period of time between the pages of a large heavy book or under a heavy weight.

Enlarging papers come in a variety of sizes and types ranging from approximately 3½" x 5" up to over 16" x 20" in cut sheets, or even larger sizes in rolls to provide the best surface for your needs. The most common paper stocks are single or double weight. The various manufacturers of enlarging paper will provide free, or for a nominal cost, small pamphlets that describe the characteristics of the different papers available. A knowledge of the various papers available is important to the serious photographer since sometimes a certain paper can be the difference between an ordinary print and one that is really special.

One characteristic of enlarging paper is speed or the emulsion's sensitivity to light. Contact printing papers use silver chloride emulsions which are relatively slow. Enlarging papers have a mixture of silver chloride and silver bromide in the emulsion which makes them faster than contact papers. Papers with a higher percentage of bromide will be faster than those of pure chloride or with lower proportions of bromide.

A second very important characteristic is contrast which gives differences in brightness between various components of the image. In other words it is the contrast between the light and dark areas of the print. A print that consists of mostly middle gray tones without any clear whites or blacks will be low in contrast. If the distinction between the whites and blacks is extremely harsh, then the print may be too contrasty. Generally one strives for a print that has a complete or nearly complete range of tones from white through gray to black. Papers usually come in a graded series of contrasts ranging from number 0, which is extra soft, up to number 6, which is extremely contrasty. Choosing the proper paper contrast can be a difficult problem, and experience is often the only method of learning which grade to use in a particular situation. Sometimes it is only after seeing a completed print done on several grades of paper can the correct one be selected. However, one can generally use a No. 2 grade of paper with a negative that is normal in contrast. When printing a hard or very contrasty negative, a soft paper such as No. 0 or 1 should be used. If the negative is very flat or low in contrast, it will usually require a No. 3 or 4 grade of paper to make a satisfactory print. If you don't want to stock many different grades of paper, then you might try using polycontrast paper. A single box of polycontrast paper can produce the entire range of contrasts by using a special set of filters that fit between the light source and the paper. When polycontrast paper is used without a filter, it will give about the same results as a No. 2 paper or approximately normal contrast.

Photographic papers also come in a variety of surface textures such as glossy, semi-matte, matte, tweed, etc., and several tints or paper colors such as gold, silver, and an assortment of pastel colors. The emulsion tone can also vary from cold type papers having dark blue-blacks to warm papers which have more brownish-blacks.

The recently introduced resin coated papers are beginning to revolutionize the darkroom. Although RC papers presently have some disadvantages, they do speed up all of the processing procedures and eliminate the drudgery of washing and drying. The emulsion is coated on a medium-weight, resin-coated base. Since this type of base does not absorb the processing chemicals and water to the same degree as do the conventional fiber based papers,

processing takes much less time. The glossy surface papers dry to a perfect glossy finish without the use of a ferrotype plate, lie flat during processing and drying, and don't crack or tear as readily as standard papers often do.

The information in this section has been concerned mainly with the preparation of a standard or "straight" enlargement. However, sometimes it is necessary to use control or creative enlarging techniques which can often make the difference between a mediocre print and one of high quality. These special techniques include such procedures as dodging, cropping, flashing, vignetting, combination printing, texture screens, burning-in, paper negatives, solarization, and toning. It is simply not possible to adequately discuss all of these techniques in this type of manual. There are a number of excellent publications on creative photography that describe these techniques, and indicate the situations where each one is the most useful. Consult Chapter X "Useful Literature for Photography" for some references that will be helpful in learning to use creative techniques in the darkroom.

After going to all of the work to get a quality black and white print finished and mounted (see the next chapter), you have a great deal of time and money invested in the project. It is very prudent at this point to consider protecting your investment, especially if the print is to be exhibited where smoke, finger prints, etc. may cause a problem, or if the print is going to receive excessive handling.

One excellent way to protect a print is to mount it behind glass or clear plastic in a frame. If this is not desirable or feasible, then consider waxing the print or spraying it with a clear protective spray. The waxing can be accomplished by applying a thin, even coat of household paste wax or liquid wax with a smooth cloth. When the wax is dry, rub it down with a clean, soft piece of cloth such as flannel. Matte prints can be protected by spraying the surface carefully with a clear spray such as Krylon Crystal Clear No. 1303 or a good decoupage finish spray. Spray the prints with an even, sweeping motion being very careful not to apply too much spray at any one point on the print. If you spray on too much at one time, it will tend to run and cause a ripple appearance. It is far better to spray on several thin coats, and let each coat dry completely before applying the next one.

CHAPTER IX
A FEW SUGGESTIONS FOR USING PHOTOGRAPHY

At any level in the educational arena, photography can serve a valuable and significant role as a teaching tool for the instructor as well as a learning tool for the student. If photography is to be used by both the teacher and student, it does present an additional expense for the personal and departmental budgets, plus a commitment to learning the important aspects of the photographic process. However, it is such a unique learning tool and tremendously untapped educational resource that the added expense and commitment must be viewed with the potential benefits for both the student and teacher clearly in mind. Thus, this section is intended to illustrate the important role that photography can play in the educational experience by serving as an introduction to, as well as an extension of, the appendix which lists a number of excellent examples for ways that photography can be used in the school setting. It is also intended that these initial examples serve as a ferment for the generation of more and better ideas by those who use this manual. It is further hoped that these new ideas will somehow be passed around the educational community through workshops, word of mouth, and various types of newsletters so that maximum educational use can be made of all aspects of photography in a variety of different educational settings.

A very stimulating and educational use for photography that can be utilized by every grade level and for any subject area is the "What is it" series. Everyone has probably seen some examples of this type of identification game at one time or another. Either a picture of some common item is photographed at an odd angle to make its identification difficult, or a photograph of some item that represents a story or provides a learning experience is displayed for a specified period of time. This gives the student the opportunity to identify the photograph(s) on display as well as a chance to discuss it with fellow students. This also provides the opportunity for the student to visually associate and imprint the desired learning experience. The versatility and potentiality of this learning tool is only limited by one's imagination. The source of pictures can be ones photographed by the teacher and/or students in natural or set-up type situations or simply pictures cut out of magazines and newspapers. An excellent and very quick way to display pictures for this purpose is to use a clear plastic frame that has a heavy cardboard insert that snaps in and out to facilitate putting in and removing pictures (e.g. Kleer Frame or North American Enclosures, Inc.). Another good method is to use Montana Mat Mounts in which the picture can be placed between an overlay and a stiff cardboard back (the picture can be held in place with several small spots of glue or by using several small pieces of Scotch tape that have been rolled into cylinders and attached to the picture.)

The use of 2 x 2 color slides or black and white projection slides (see Chapter II Film Types and Filters) can add a great deal of interest to any classroom presentation. It doesn't take very long to accumulate a library of useful slides from a variety of sources. For example, a series of slides

from a summer vacation can be used in a geography class, literature class, language class, etc.; a field trip to a place of special interest can serve as a visual source for future years; slides made from special printed materials can add a visual dimension to what otherwise might be a subject difficult to explain by words alone; and the list can be expanded almost indefinitely. These same slides can serve to make photographic prints if it seems more desirable to prepare a display on a bulletin board or heavy mounting board (for easy storage) for the students and/or public to have easier access to viewing them.

Another way that the slides or prints can be utilized is to use them as the basis upon which students can write or recite a story that they develop from observing the photographs. It might also be desirable to have the students produce both the photographs and the story to go with them as a project designed to let the student demonstrate his or her originality. Some of the simple cartridge cameras (e.g. the Kodak Instamatic) or a Polaroid camera can be used to teach elementary students how to take photographs, and provide them the opportunity to take pictures for developing a story, recounting a trip, or producing an exhibit of their activities.

Photography can also be used to document local attractions, concerns, and problems. In this age of ecological awareness photography can play a key role in bringing pollution problems as well as every day concerns to the attention of everyone. It can serve as a key teaching tool as well as a way for students to demonstrate area concerns and problems. The latter can serve as a focal point for an ecology club or a group of concerned students to get other citizens informed of local problems and/or to demonstrate the benefits that can be derived from ecologically sound practices.

The drama department can effectively use 35mm photography for recording special scenes in a student play. This can be done easily during the dress rehearsal when the photographer has freedom of movement around the stage, or during one of the regular production nights. This will make a beautiful record of the plays produced during the years, as well as providing a library of stage settings and lighting effects that can be useful for teaching new technical crews the finer points of staging a successful play. In most cases excellent results can be obtained with the regular stage lighting by using Kodak Ektachrome 160 Film (tungsten). This film has a normal ASA rating of 160, but it can be exposed at ASA 320 if it is processed by a special procedure called "push" processing (see Chapter II "Film Types and Filters"). In order to obtain this increase in the effective film speed provided by the special processing, all exposures on the roll must be made at the higher ASA rating. Even with the higher film speed, you may have to resort to long exposure times for certain situations, and it is important to remember that a firm support is needed for the camera to prevent blurring. This can be accomplished by using a sturdy tripod and cable release, or by supporting the camera firmly on the back of a chair, edge of the stage, etc.

A flash attachment can be used in place of the faster film speed. However, both approaches have advantages and disadvantages that must be taken into account before deciding which technique to use. For example, the use of a flash unit will not permit registering the subtle lighting effects created by the lighting crew. The flash will wash out the spots

and change the overall mood of the lighting as seen by the audience. The use of Ektachrome without flash will provide an excellent record that can visually demonstrate the effectiveness of various lighting setups in a particular play. Also the flash can be very disruptive to the continuity of the play, but the long exposure times that might be required without a flash can also be very disadvantageous. This type of photography can take advantage of different focal length lenses to produce a variety of effects. However, a very fast 55mm or a wide angle lens will probably give the most satisfactory results.

A properly organized and operated photography club can provide students with an excellent setting in which to learn a great deal about photographic procedures and techniques as well as providing them the opportunity to develop self-expression. In addition the club can provide an arena where students can exchange information and ideas plus develop a healthy competition by having photography contests both within the club and possibly between clubs in neighboring schools. Finding a suitable location for a club display and setting it up can develop responsibility and community awareness.

Photography can also be a tremendously important resource for anyone recording research data, writing a research paper, recording observations in the field, displaying original work at a science fair, etc. A photography display that is well prepared and appealing can add another important dimension to whatever the exhibitor is trying to portray to the viewers. Many will find that the Polaroid system can be very useful for some of these types of ideas. The quickness and ease with which one can get the finished results of his or her efforts can often outweigh the disadvantages of this type of photography. It can also make the preparation of a display much easier, although the small print size may not always be advantageous when the display must be viewed from a distance.

This is only a very brief introduction to the many ways that photography can be important and useful in the educational experience. The appendix will serve to suggest many more additional ways that photography can be useful, and it is hoped that they might stimulate the users of this manual to develop unique ideas to fit their own individual needs and situations.

In order to properly conclude this chapter it is felt that a few suggestions on ways to mount and display prints would be a useful addition to any ideas on how to use photography in the classroom and laboratory. As with so many other photographic techniques, there are many good and different ways to mount prints for display. Therefore, the attempt here will be to only mention a few of the ways that prints can be handled for display purposes.

Before going to the effort of mounting a print be sure that it is a quality print free of defects such as blemishes and spots. A very soft pencil can sometimes cover minor spots, but a good dye spotting kit is indispensible for the major defects. Follow the directions carefully and be prepared to practice a great deal in order to become proficient at this technique. The simplest and probably the most useful way to mount prints is to attach them to a heavy weight mounting board. This can be done by a variety of relatively easy methods such as a good quality spray

adhesive, heat sensitive dry mounting tissue, positionable mounting adhesive, or print mounting cement (for small prints only). Never use ordinary glues or craft cements for permanent mounting since with time they have a tendency to deteriorate and/or discolor the print. However, if the prints are only to be used for a couple of years and discarded, then ordinary wall paste or Elmer's white plastic resin glue will suffice (these two work very well for mounting prints on wood or masonite).

A relatively new and fast way to mount photographs, maps, news articles, etc. to mounting board, walls, doors, or other reasonably smooth surfaces is the Scotch ATG 750 tape dispenser using special adhesive transfer tape. The applicator transfers a film of adhesive to almost any surface upon contact. The object can then be placed on the mounting board or other surface which will bond it tightly and smoothly in place.

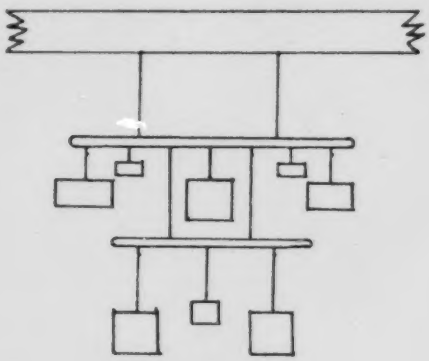
After attaching the print to the mounting board it can be trimmed using a good quality straight-edge and very sharp knife. Be careful not to damage the print surface with the straight-edge which should be free of rough surfaces and absolutely clean. Each cut should be made with a series of light strokes keeping the straight-edge over the picture area to prevent damage to the print image. It is also very important to make certain that the straight-edge is placed correctly and held firmly in order that the edges of the mounting board remain parallel. The edges can be made smooth by lightly sanding with a fine grit sandpaper, but be certain to stroke away from the emulsion in order to avoid fraying the edges. Some photographers prefer to trim their prints without any boarders; some like to cut the components separately and mount the print on an oversized board so that it is seen against a plain background (the proper choice of a color can enhance the photograph in many ways) while others prefer to put the mounted print behind a cut out opening called a mat. The mat can be cut by hand using special guides and a piece of good quality mat board or purchased already pre-cut. No matter which method is used many also prefer to blacken the edges of the finished mount by carefully treating them with a wide felt marker containing water-proof ink.

The use of wood or metal frames with or without glass can also be used to enhance and protect a fine photograph for display purposes. It is also possible to place glass over the mounted print and carefully tape the edges to make a handsome display. The clear plastic frames with the cardboard inserts mentioned earlier in this section make a very practical and beautiful way to display photographs. There are also multi-sided plastic photo frames available that are useful for displaying several small sized prints at one time. The list of ways to mount and/or display prints could go on and on, and the limitations are reached only when the photographer runs out of imagination.

When displaying photographs it is often desirable to prepare a neat label for each photo and/or a large sign to identify the exhibit. Typing or printing with lettering guides (e.g. Rapidograph pen with special guides, a LEROY set, or regular lettering stencils) on self-adhesive labels, light weight mat board, or heavy paper can make a very attractive label and sign. Many of the available guides come in a wide variety of styles and sizes that provide a range of choices. However, for preparing a large and conspicuous heading on a display board the old stand-by of cutting letters out of colored construction paper is still hard to beat. There are also several

varieties of prepared lettering sheets (transfer style) that can be lined up and the letters rubbed off to make a quick, easy transfer of the letters to almost any surface. In order to make any of these processes permanent and to protect them from damage, they can be sprayed with any good clear acrylic or photo sealer.

An interesting and attractive way to display photographs in the office or classroom is the mobile. Photographs can be mounted on both sides of heavy mounting board (usually small sizes such as 5 x 7 and smaller), the edges blackened with a waterproof marker, a small hole drilled in the top center area, and a piece of fishing line or very flexible wire strung through the hole. A painted or stained wooden dowel (or heavy, stiff wire) is hung in a horizontal position from the ceiling by one or two pieces of soft, thin wire or black string. The photographs are hung from this dowel or wire using pieces of string or wire of different lengths as well as another shorter dowel or heavy wire which can be used to hang more photographs. The different possible arrangements are almost infinite, and add to the originality of each display. The following sketch offers one possible arrangement:



CHAPTER X
USEFUL LITERATURE AND PHOTOGRAPHY

In a brief and introductory publication such as this one, it is impossible to adequately cover all of the subjects mentioned or to discuss all of the topics that might be of interest to the beginner or the advanced photographer. However, if this manual should help you in any way to develop a genuine interest in photography, then continued practice for technical improvement and development, plus an expansion of photographic ideas by attentive reading of photography books and magazines will provide a steady growth in your enjoyment and technical abilities. The following list of books and pamphlets are designed to provide the serious reader with both general and technical information to assist in photographic growth as well as good material for a reference library:

1. Books and Pamphlets published by Kodak (for a more complete list available plus a current price list, write Eastman Kodak Co., 343 State Street, Department 454, Rochester, New York 14650).

   (a) Kodak Darkroom Dataguide (R-20)

   (b) The Here's How Book of Photography (AE-100)

   (c) Bigger and Better Enlarging in Color and Black and White by D. Nibbelink and R. Anderson (AG-19; American Photographic Book Publishing Co.)

   (d) Photomacrography (N-12B)

   (e) Close-Up Photography (N-12A)

   (f) Photography Through the Microscope (P-2)

   (g) Composition (AC-11)

   (h) Advanced Camera Techniques for 126 and 35mm Cameras (AC-56)

   (i) Managing the High-School Camera Club (AT-50)

   (j) Kodak Filters for Scientific and Technical Uses (B-3H)

   (k) Creative Darkroom Techniques (AG-18)

   (l) Construction Materials for Photographic Processing Equipment (K-12)

   (m) Student Pictures for School Publications (AT-13)

   (n) Classroom Projects Using Photography, Part I: For the Elementary School Level (ED11-1)

   (o) Classroom Projects Using Photography, Part II: For the Secondary School Level (ED12-1)

   (p) Basic Chemistry of Photographic Processing (Z-23-ED) Part I: What Processing Chemicals Are Made Of; Part II: How Processing Chemicals Work

   (q) Basic Photographic Sensitometry Workbook (Z-22-ED) - Good resource for use in a physics class

2. Books in the Petersen's Series (Petersen Publishing Company, 8490 Sunset Boulevard, Los Angeles, California 90069)

   (a) Petersen's Guide to "Photo Equipment You Can Make"

   (b) Petersen's "Photo Equipment You Can Make - Volume 2"

   (c) Petersen's "Big Book of Photography"

   (d) Petersen's Guide to "Photo Lighting Techniques"

   (e) Petersen's "Close-Up Photography"

3. Other Useful Publications:

   (a) Eaton, George T. Photographic Chemistry - In Black and White and Color Photography, Morgan and Morgan, Inc., Hastings-on-Hudson, New York 10706. Library of Congress #65-27034.

   (b) Feininger, Andreas, 1965. The Complete Photographer, Prentice-Hall, Englewood Cliffs, N. J.

   (c) Feininger, Andreas, 1975. The Creative Photographer, Revised Edition, Prentice-Hall, Englewood Cliffs, N. J.

   (d) Gassan, Arnold, 1972. Handbook for Contemporary Photography, Sierra Club, San Francisco, California.

   (e) Maye, Patricia, 1974. Fieldbook of Nature Photography, Sierra Club, San Francisco, California.

   (f) Rhode, R. B. and F. H. McCall, 1971. Introduction to Photography, 2nd Edition, The Macmillan Company, New York, New York.

   (g) Swedlund, Charles, 1974. Photography: A Handbook of History, Materials and Processes, Holt, Rinehart and Winston, New York, New York.

   (h) Upton, B. and J. Upton, 1976. Photography, Little, Brown and Company, Boston, Massachusetts.

   (i) Photography as a Fourth "R", 1977. Published by the Educational Information Division of Popular Photography, One Park Avenue, New York, New York 10016.

Although photographic magazines tend to be quickly outdated, they do provide a great wealth of current information that can be very valuable. They usually provide the reader with a great deal of technical data on new photographic equipment, hardware, and supplies as well as useful hints on techniques and examples of current trends in photography. The following examples are three popular and technically oriented magazines that are published each month:

   (a) Modern Photography, The Billboard Publishing Co., 165 West 46th Street, New York, New York 10036.

   (b) Popular Photography, Ziff-Davis Publishing Co., 1 Park Avenue, New York, New York 10016.

   (c) Petersen's Photographic Magazine, Petersen Publishing Co., 8490 Sunset Boulevard, Los Angeles, California 90069.

Sources for Photography Supplies

Many of the larger cities in the state have photography stores where you can purchase equipment, supplies, and literature as well as obtain answers to many of your photographic questions. If you do not have easy access to a photography store, or if the one you normally patronize does not carry the item(s) you need, then it may be necessary to use a reputable mail order establishment. One that has served the author well for a number of years is Porter's Camera Store, Inc., Box 628, Cedar Falls, Iowa 50613. They will send a large, free catalog to those who request it, and from this catalog one can obtain items by ordering through the mail as well as using their free telephone order number. They also provide a very useful and free consulting service for their customers (mail only) that provides answers to questions concerning photographic procedures and/or equipment (see their catalog for details).

Another excellent mail order house that carries a fairly complete line of photographic items is Solar Cine Products, Inc., 4247 South Kedzie Avenue, Chicago, Illinois 60632. It is also possible to find a number of advertisements in the various photography journals where equipment and supplies can be ordered. One can take advantage of some very good prices, but be very careful where you order, and make certain that you are ordering new equipment and/or items that are not long outdated.

APPENDICES

TEACHER ACTIVITIES AND STUDENT RESEARCH PROJECTS

submitted by:
Bruce Esser
formerly with Omaha Public Schools

1. Stamps, Science, and Photography

Use stamps commemorating scientists or scientific events to make slides to introduce slide presentations concerning a particular topic. This approach will help to humanize science by giving the student an image of what a scientist looks like. In addition, the clothing and surroundings give the student a feel for the time period involved. For the stamp collectors in the audience, it draws upon their hobby interests in a unique way.

Note: See Chapter V "Close-Up Photography and Photomacrography" for a discussion of the technique utilized for preparing these slides.

2. Have interested students research techniques and uses of underwater photography.

3. Have interested students research techniques and uses of aerial photography.

4. Assign interested students a research project in infrared photography.

5. Have interested students research the techniques of old time photography processes. Cyanotypes, tintypes, and gumbichromates would be good topics to begin with.

6. Assign interested students to research processes involved in remote sensing.

7. Photography as a Vocation

For most students photography is an avocation, a diversion which provides enjoyment and entertainment. For some students, however, photography is much more than a hobby; it is to them a way of life. For these students proper guidance concerning careers in photography and methods to obtain these careers must be made available.

Careers in photography are many and varied. In addition to the usual careers in professional photography and cinematography, the student who combines an interest in science with his interest in photography should consider a possible career in photo science.

The photo scientist may be involved in a science in which photography is an integral part of the research process. Such jobs include applications methodology and the development of new photographic techniques. Radiography, photogrammetry, experimental pathology, and meteorology are just a few of the many sciences needing photo scientists on their research team.

Other opportunities for the photo scientist deal directly with the photographic process itself. Lens design, photo instrumentation, photo chemistry, and film analysis are all examples of this type of career.

There are over 700 institutions offering instruction in photography. These vary widely in emphasis and education. The prospective photo scientist should pay particular attention to the institutions curriculum in photo science as many institutions are interested in training professional photographers, not photo scientists. A good guide to institutions offering courses of study in photography has been compiled by Dr. C. W. Horrell of Southern Illinois University. This book can be acquired from the Eastman Kodak Company; it is publication T-17. It provides a survey of all the institutions which provide photo education with a listing of their curriculum and degree offerings.

PHOTOGRAPHY TO ENHANCE ENVIRONMENTAL SCIENCE

written by:
Carl Wolfe and John Farar
Nebraska Game & Parks Commission
Lincoln, Nebraska

1. Land Use Changes - Document the development of housing from farmland, etc. through occupancy.

   Objective: To show the impact of human use on a landscape.

   Situations to Depict:
   1. Loss of natural vegetation
   2. Erosion from land shaping
   3. Change in vegetation and related organisms that use habitat
   4. Water retention changes from natural vegetation to asphalt/concrete increases

2. Seasonal Vegetation Changes - Document the changing seasons by utilizing a selected site, i.e. park, backyard, etc.

   Objective: To demonstrate the color, mood, and structural changes brought about by seasons.

   Situations to Depict:
   1. The branch of a selected tree
   2. A landscape
   3. A fruit-producing tree such as a flowering crab, plum, or chokecherry

3. Sources and Types of Pollution - Document the various ways that pollution occurs and how it affects others.

   Objective: To portray point sources of pollution and to depict ways that others are affected.

   Situations to Depict:
   1. A municipal sewage operation showing strengths and weaknesses
   2. A smoker - how he/she acquires, impacts others, and disposes of residue
   3. A beverage can user
   4. A city landfill operation
   5. A fish kill along either small or large water course

4. Unusual Flora/Fauna - Document existence of living organisms in unusual situations.

   Objective: To demonstrate the adaptibility of various organisms for unique habitat niches.

Situations to Depict:

1. Unusual nesting/roosting (living conditions) of urban wildlife such as the starling, sparrow, crow, etc. For example, the use of masonry chimneys for warmth in winter
2. Plants in unusual places such as city alleys, rights-of-way, etc.

5. Plant Measurement - Document the height, arrangements, associations, etc. of plants.

Objective: To provide a quantification method for measuring vegetation.

Situations to Depict:

1. Number of plant species in a given unit of measurement (m^2)
2. Vertical relations of vegetation

USES FOR BLACK AND WHITE ENLARGEMENTS

submitted by:
Don Woodburn
Science Consultant
Nebraska Department of Education

1. Display pictures of student research topics for "Parent Night." This is particularly useful in physical science classes to depict students working in the laboratory setting.

2. Bulletin board games such as "The Unknown Object." A good inquiry activity, especially for junior high school students. Hallway display boards can create interest in science among non-science students as well.

   For example, students may be asked to explain science phenomena on Monday such as a closeup photo of a crystal. A follow-up picture showing an entire rock identifies the rock later in the week.

   Some pictures can be partially covered to present a problem situation. Inquiries may be directed at the teacher with the answer held until the photo has been displayed several days. These game-like activities encourage students to think, and become better decision makers. Discussions in class can take the activity beyond a mere game and into the teaching arena.

3. Depict various science processes in action.

4. Display enlargements of various science phenomena such as storm, frost, dew, erosion, etc.

5. Photos of various insect life cycle stages to display the process of metamorphosis.

6. Photos of different animals, each representing a different phylum.

7. Photos depicting rapid change in plant growth caused by student experimentation.

8. Display enlargements of parts of organisms. Insects, flowers, etc. would work well.

EXAMPLE TOPICS SUITABLE FOR DEVELOPING SLIDE SETS FOR USE IN THE LIFE SCIENCES

1. Drosophila mutants depicting body, wing antennae, and eye mutations. (See Chapter V "Close-Up Photography and Photomacrography")

2. Drosophila life cycle series depicting cycle from egg laying through young adult.

3. Protozoa slides taken of very common organisms such as paramecium, rotifer, euglena, etc. (See Chapter V "Close-Up Photography and Photomacrography")

4. Earthworm anatomy showing internal and external parts. (See next appendix item describing techniques for photographing a frog dissection.)

5. Flower set to include various types of flowers and dissected flowers to enhance study of flower parts.

6. Monocot vs Dicot flowering plants. This series could contrast monocot groupings of these parts vs four/five groupings of Dicots.

7. A Nebraska grasses series illustrating native grasses such as Indian Grass, Little Blue Stem, etc.

8. Trees/bushes in our city series to assist students in identification of familiar trees.

9. Plants in your back yard. A series depicting typical "weeds" in our lawns such as clover, dandelion, crabgrass, etc.

(NOTE: This list could be endless and is provided only to serve as a starting point for you to brainstorm ideas suitable to the units you teach.)

PREPARATION AND USE OF FROG DISSECTION SLIDES

(Written by George Royce and James Shank of the Omaha Public Schools, with special acknowledgement to Roger Macklem for the original procedure)

Explaining the procedures involved in the dissection of anesthetized or preserved specimens can be a complicated and confusing matter. Because of the time factor involved, a clear and concise explanation is especially important when dealing with animals which will be used for physiology investigations prior to dissection. Students who are confused about how to "open" a specimen will have insufficient time to carry out both the physiology investigation and dissection in one laboratory period. The purpose of this paper is to explain the preparation and use of slide sets to show the dissection of anesthetized or preserved frogs. With minor modifications, this procedure can be used for other types of specimens.

The equipment needed to produce the slide set includes: a large specimen of the organism to be dissected, typical dissecting instruments used with a textbook or teacher-prepared directions, a 35mm single lens reflex camera, a copy stand or tripod, photo floodlights, plastic coated wire, dark construction paper, close-up rings or bellows attachment, and daylight or tungsten slide film. Using sunlight as the light source eliminates the use of photo flood lights, and you may use daylight film. If you use tungsten photo floodlights, tungsten film will be needed or you can use daylight film with the appropriate lens filter. Daylight (blue) photo flood lights are also available.

Assemble all the materials and be thoroughly familiar with the use of the 35mm SLR camera before proceeding. A clear outline of what will be shown in every frame of the slide set should be developed. This is sometimes called a "storyboard." If your storyboard outline is well prepared, you will avoid needless shots and you will not miss important steps in the dissection. Plan to spend two to three hours preparing for and taking 30-40 good slides.

Procedures:

1. Cut the dark construction paper to fit the bottom of the dissection tray. This will provide an uncluttered, non-reflective background.

2. Place the camera on the copystand or tripod and focus on the dissection tray with dissecting instruments placed in it. You may wish to start your presentation showing the dissection and all the needed equipment. Set up the appropriate lighting based on the type of film and lighting you are using.

3. Take the picture of the equipment for an introductory slide and proceed to set up the dissecting tray to receive the specimen. Place the specimen in the tray in the appropriate position. Do not pin it down at this time. You will want to show this in later slides.

4. Fill the dissection tray with water to within five millimeters of the top. This is an important step as the water will reduce the glare that is reflected by the various angles of moist skin. Adjust the camera so that the plane of the dissecting tray is parallel to the plane of the lens of the camera. Adjust the photo floodlights at approximately 45 degrees from the surface of the table or until minimum glare is achieved when viewed through the camera.

5. Proceed with the dissection as outlined in the student procedures. Take slides for each process that you feel is important to the dissection. Properly fastening the animal to the dissection tray might be a first step. Always allow the movement of the water to cease before taking the picture. As you begin to cut into the specimen, the water may turn cloudy; change the water as is necessary.

6. Once you have exposed the viscera of the animal, you will probably wish to focus on specific organs. To do so will probably require adding a close-up ring(s) or using a bellows attachment (See Chapter V). To point out specific organs a plastic coated electrical wire has several advantages. It easily attaches to a ring stand and can be bent to various angles. Since it can be attached to a stable support, the use of a plastic coated wire diminishes the disturbance of the water's surface that would be prevalent if a hand held pointer were used. If you wish to point to more than one object in a frame, use different colored wires for clarity. To avoid confusion, it is best to point to only one organ per slide. These types of slides can be used in a post-lab quiz.

Suggestions on the Use of the Slide Set

Any slide set on dissection should be used to enhance the directions given to students. The slide set should NOT be used in lieu of the actual dissection activity. Even the best of slide sets cannot replace the actual interest and motivation generated by a well run physiology or dissection laboratory. You will probably wish to show only the minimum number of slides necessary for a prelab. Usually these slides simply show how to properly handle, secure, and make the initial incisions on the specimen. The remaining slides may be used in the post-lab discussion. If the entire set is shown before the laboratory experience, student interest in the activity could be reduced. If you give students laboratory-practical examinations, you may wish to have your slides turned into color prints. These could be placed at various stations throughout the room along with the actual specimens.

USES FOR SLIDES IN EARTH SCIENCE

submitted by:
Mr. M. J. Nelson
Retired Science Teacher
Holdrege, Nebraska

1. Supplement the pictures in the text with illustrations from National Geographic Magazine, other texts, magazines.
2. Bring the best in calendar pictures to the classroom.
3. Make it possible for all to see charts and graphs from newspapers, magazines, etc.
4. Copy road maps for wall enlargements.
5. Orientation map series - (1) Take a picture of a map of the United States; (2) then a map of the state to be studied; (3) then a map of the specific area in that state.
6. Pictures of model drawings from other texts (such as kinds of faults, etc.).
7. Pictures of humorous postal cards showing such things as fur bearing trout, etc., to introduce new topics.
8. Pictures of fossils pupils bring and wish to take back home so you have a permanent record for school use.
9. Pictures for laboratory rules and no-no's. (These can be on the humorous side. Kids love them.)
10. Travelogues of the national parks.
11. Pictures of field trips taken by the class.
12. A lined slide that will put contour lines on any irregular surface when projected on that surface.
13. Pictures of mythological characters connected with earth science (Vulcan, Nepture, Proserpina, etc.).
14. Pictures to show progressive development of earth forms (young to old stream) before and after glaciation. Pictures can be taken together and then separately to give continuity.

SLIDES OR BLACK AND WHITE ENLARGEMENTS FOR USE IN EMPHASIZING LABORATORY SAFETY

submitted by:
Donald Woodburn
Science Consultant
Nebraska Department of Education

1. "What's wrong with this picture?" Develop a series of photos depicting incorrect lab set ups, followed by correct procedures. For example, take pictures of a bunsen burner with a ring stand affixed eight inches above the flame. Ensuing pictures would depict proper adjustment of the ring holder to a suitable height above the flame.

2. Depict all stages in a given lab procedure, where following instructions is critical to the safety of students.

3. Cartoon sketches (drawn by art students) depicting numerous situations (example: heating liquid in a test tube).

4. Proper set up procedures for laser studies.

5. A slide series to orient new students to major precautions and safety devices in the lab. This could be used both at the beginning of the course and as a self taught series for students entering your class in the middle of the school year. This might be useful as a review for students not following safety rules also.

6. A slide series of the laboratory equipment in the lab. This is especially useful for seventh grade students and most courses with equipment unfamiliar to new students.

7. A slide series depicting the steps involved in setting up or tearing down a set of equipment. This is useful not only for student safety, but also for the safety of the equipment being utilized. An example is the picture in this publication depicting a set up for microphotography.

8. A slide series showing the steps involved for the proper use of the fire extinguisher located in the lab.

9. A slide series showing the proper method of rinsing the eyes at a sink or eyewash fountain in case of acid or alkaline splash to the face.

10. A slide series illustrating proper techniques in handling glass tubing such as placing the tubing in a one-hole stopper.

TESTING WITH SLIDES

submitted by:
George Royce
Omaha Public Schools

(Content corresponds with the ISCS Unit 3, "Crusty Problems" text. This example illustrates a good method of evaluating student perception of a concept.)

1. (Slide 1) The volcano is throwing liquid lava into the air. This forms a rock called pumice. Pumice is
   A. very heavy and made of large crystals.
   B. frothy, full of tiny air holes and light weight.
   C. very similar to iron and gold.
   D. smooth to the touch and very heavy.

2. (Slide 2) The lava flowing down this hill will cool to form a(n)
   A. sedimentary rock.
   B. metamorphic rock
   C. igneous rock.
   D. none of the above are correct.

3. (Slide 3) This is granite. It has interlocking crystals that are randomly spaced throughout the rock. This rock was probably formed by
   A. slow cooling of liquid rock.
   B. rapid cooling of liquid rock.
   C. sand and silt being glued together with calcium carbonate.

4. (Slide 4) This is a picture of one of the Mono craters found in California. The shape of these suggest that they were formed by
   A. slow uplift of rock layers over many millions of years.
   B. volcanic eruptions.
   C. by sedimentary action.

5. (Slide 5) These ripple marks were found high in a mountain area and tilted. The best explanation for these ripple marks would be
   A. the marks were formed by the wind's actions over millions of years.
   B. the marks were formed by rock weathering caused by water over millions of years.
   C. the marks were formed in an ancient sea which later dried up and exposed the mountains.
   D. the marks were formed in an ancient sea. The land was forced up and tilted by pressure beneath the earth.

6. These rocks have interlocking crystals, but they also show signs of layering of the crystals. They are probably
   A. igneous
   B. metamorphic
   C. sedimentary
   D. none of the above.

7. These rocks were formed in layered slabs. When acid is added they bubble. They are probably
   A. igneous
   B. metamorphic
   C. sedimentary
   D. none of the above.

8. This V-shaped valley was probably caused by
   A. glacial action
   B. river action

9. This U-shaped valley was probably caused by
   A. glacial action
   B. river action

10. Over many years this material will probably form
   A. granite
   B. obsidion
   C. sandstone
   D. igneous rock.

AUTOTUTORIAL SLIDE TAPE PRESENTATION

submitted by:
Don Woodburn
Science Consultant
Department of Education

Teachers may "can" a lab by using this technique. Students may use the slide tape presentation without further teacher input in doing the laboratory exercise. These programs are especially useful with supplementary labs (either developmental or challenge), produced over the years.

When a student expresses a special interest in a topic, he/she can pursue the topic by beginning with the slide-tape. In this way, the student proceeds without constant teacher input, and the majority of the class may proceed with the group process.

Slide tape programs are also obviously useful for unit introductions, review purposes, and for make up work when students are absent.

A partial sound/slide script is included below, followed by a story board. The story board can be duplicated for use in developing your own programs. It would also be useful if you plan to assign groups of students to create programs.

Laboratory Orientation

Content corresponds with the I.M.B. text, (Introduction of Man and Biosphere) dealing with "Energy From Foods." This partial slide/tape series is just an example of the numerous similar projects that could be developed to enhance your student's science experience. This partial slide tape was developed by George Royce of Omaha Public Schools.

SLIDE	AUDIO
1. Title slide "Energy From Foods"	This is the tape for the slide set "Energy From Foods." When you hear this sound (demonstrate audio slide advance sound), go to the next slide. This slide-set will help you to understand how you can find the number of calories for some common foods using simple equipment.
	ADVANCE SOUND
2. Students at lunch	Every day you consume a great many different types of food. Why? (Pause) You might answer "Because I enjoy eating" or "Because I get hungry." But why does your body need

this food? (Pause about 7 seconds) If you said because you need energy, you are correct. Every living cell in your body needs energy to do the things the cells were meant for.

ADVANCE SOUND

3. Muscle cells

For example, these are muscle cells. They use the food you eat for energy. By using this food energy, they help you to do the things you do every day.

ADVANCE SOUND

4. Students in gym

You use this energy in your muscles to play hard in gym.

ADVANCE SOUND

5. Students in the classroom

Or to work hard in class. Everything you do requires energy.

ADVANCE SOUND

6. Slide shows different foods to be tested

If everything you do requires energy, and you get energy from food, then it only makes sense that you should be concerned with how much energy is in a particular type of food.

ADVANCE SOUND

7. Definition of a calorie

We measure heat energy in calories. A calorie is the amount of heat energy needed to raise 1 milliliter of water 1 ^{o}C. If you do not understand what milliliter or ^{o}C means, the slide set may be stopped at this time to allow your teacher to explain.

ADVANCE SOUND

8. Water being heated with thermometer and chart

For instance, if 100 ml. of water was heated from 20 ^{o}C (which is about room temperature) to 37 ^{o}C (which is the temperature of your body), the amount of energy needed to do this would be 1200 calories.

ADVANCE SOUND

9. Calculation of 1200 calories

We can find this in the following way: 37 ^{o}C - 20 ^{o}C = 17 ^{o}C. We then multiply the temperature difference (17 ^{o}C) by the amount of water which is 100 ml. 17 ^{o}C X 100 ml. of water = 1700 calories.

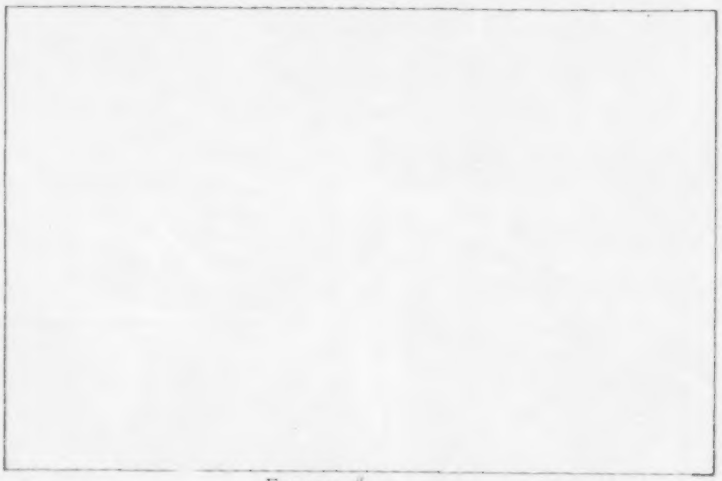
ADVANCE SOUND

SLIDE	AUDIO
10. Diet book	You have probably heard of calories. You may have seen calories listed in diet books and on cereal package labels.
	ADVANCE SOUND
11. Calories defined	The nutritional calorie or large Calorie is really 1000 times larger than the small calorie that scientists often use. You can easily convert from small calories to large Calories by simply dividing by 1000. For instance, 4000 small calories divided by 1000 equals four large Calories.
	ADVANCE SOUND
12. Show foods that will be used	If you ate 50 grams of each of the foods pictured here, which do you think would give you the most energy?
	ADVANCE SOUND
13. Calorimeter and equipment	Using a simple calorimeter like this, you will find the number of calories found in one gram of each of the substances in the previous picture. Here is how you will do it.
	ADVANCE SOUND
14. Data sheet	First let's make a chart for our data. Make a chart just like this on your own paper. The tape may be stopped while you do this. (Long pause) Notice that the water is already filled in. We will use fifty ml. of water in this experiment.
	ADVANCE SOUND
15. Graduated cylinder	Measure 50 ml. of water in a graduated cylinder. Remember that you read the water level at the bottom of the dip in the water called the meniscus.
	ADVANCE SOUND
15a. Cylinder close-up	Here you can see the bottom of the dip or meniscus is at the 50 ml. mark.
	ADVANCE SOUND

SOUND/SLIDE - Story Board Pad

Frame # _____

Frame # _____



Frame # _____

PAPER NEGATIVE PHOTO PRINTS

submitted by:
Carl Clark
District 66 Public Schools
Omaha, Nebraska

MATERIALS

Photo paper, felt tip pen, paper towels, overhead transparency projector, glass sandwich, ditto paper, developer, stop bath, fixer, developer tray, stop bath tray, fixer tray, water dishpan.

OBJECTIVES

Students will be able to make their own photo prints.

DESCRIPTION

These prints have a stunning effect and can be used to accompany any assignment where mood is desired or as an assignment by itself.

ACTIVITIES

Prepare and arrange materials:

1. General room setting
   - A. Shut all shades to stop direct sunlight.
   - B. Turn off most of ceiling lights while photopaper is being used.
   - C. Provide for traffic patterns which keep development materials at one side of the room and the exposure materials on the other side.
2. Drawing materials for each person
   - A. Glass sandwich.
   - B. Black felt-tip pen.
   - C. Paper towel.
   - D. Piece of ditto paper cut to desired size.
3. Exposure area
   This area should have an overhead transparency projector which is located in the outer edges of the room. The light should be directed toward a wall to prevent excessive exposure of paper being used in the drawing area.
4. Development area
   - A. 3 trays placed in a row.
   - B. 1 dishpan at end of row.
   - C. Paper towels should be located.
   - D. Locate wastebasket near paper towels.
   - E. Pour developer in tray #1.
   - F. Pour stop-bath in tray #2.
   - G. Pour fixer in tray #3.
   - H. Fill dishpan 1/2 full of water.

Making a paper negative:

Make a drawing on white ditto paper with the black felt-tip pen:
Rule 1: Any black mark will look white in final print.
Rule 2: Any white area which is left will look black in final print.
Rule 3: A space must be left between areas of the same color, i.e. snow man on snow.

Making the exposure:

1. Place the drawing on the cardboard side of the opened glass sandwich. Make sure the picture is top or front side up.
2. Slide a piece of photopaper under the drawing. Make sure the emulsion side is up. The emulsion side is identified by its slight blue coloration as well as its tendency to curve upward like a rocking chair rocker when the emulsion is on top.
3. Shut the glass over the two pieces of paper carefully so as to not move them when closing. Check to see if tape on edges of glass covers image. If either problem occurs, open glass and rearrange.
4. Pinch glass together and carry to projector. Protect photopaper from bright light by placing glass against body and cardboard to the outside.
5. Place glass sandwich on projector with glass touching glass. Turn projector on and count slowly to 10.
6. Return to drawing area and remove only the piece of photopaper.

Developing the print:

1. Quickly submerge the photopaper in the developer. Watch the print change but do not hold the print against the bottom of the tray. Blank spots will result where the fingers were applying pressure. When the background turns black (usually 10-15 seconds) remove from tray.
2. Place in stop-bath and count to ten. Remove from tray.
3. Place in fixer and allow to soak for 5-10 minutes. While waiting for the soak, it is oftentimes possible to expose and develop additional prints. Remove from tray.
4. Place in water and allow to soak for 5-10 minutes. Remove from tray.
5. Pat dry between folds of a paper towel. Remove from towel and allow to air dry.

Special Notes:

1. About the photopaper:
   A. The photopaper is called Kodak repro-negative ultra thin R-1. It comes in a 100 count box measuring $8\frac{1}{2}$" x 11".
   B. This paper is not sold through regular photo supply stores. It must be purchased through the graphics supplies division.
   C. The times suggested in this presentation are a balance of time and general effectiveness. If archival quality is desired, the wash must be extended to at least 30 minutes in running water at a temperature of 65°F to 80°F.

2. Making the exposure:
   A. Exposure can be accomplished by any form of intense light source.
   B. Time of exposure must be determined for each light source by experimentation.
   C. Other materials may be used in place of the paper. Leaves, pressed plants, paper cut outs, real film negatives, photographs may also be used. In other words, any material which may be used to control the amount of light which can reach the photographer.
3. About the photochemicals:
   A. The developer may be any of the following and diluted according to package instructions:
      (1) Kodagraph
      (2) Dektol
      (3) Ektaflo Type 1
   B. Stop bath with indicator turns purple when exhausted.
   C. Replace fixer whenever stop-bath is replaced.
   D. Water should be replaced at least once per hour per 30 students.
4. Creating the print:
   A. A print which comes out too light:
      (1) Has not had enough exposure to light.
      (2) Was not left in developer long enough.
      (3) Was developed in developer which was:
         (a) exhausted - usually indicated by a dark brown or grey color;
         (b) too cold - should be used at room temperature;
         (c) improperly mixed - used wrong amount of water for dilution;
         (d) contaminated - the chemicals became mixed for some reason.
   B. A print which comes out black:
      (1) Has had the photopaper placed on top of the light resisting material instead of under it.
      (2) Has had exposure to light too long.
   C. A print which comes out of development with grey areas where white should appear usually:
      (1) Has had projector light shine on photopaper before being placed in glass.
      (2) Has been left out in room uncovered too long.
      (3) Is being used in room where sunlight is not blocked out.

SLIDES WITHOUT A CAMERA

submitted by:
Dr. Angela M. Elefante
310 Bleecker Street
Utica, New York 13501

MATERIALS

Slick magazine (Time, McCalls, etc.), 2 x 2" square of clear vinyl or slide mount, 2" x 2" square of contact brand clear transparent, warm water, spoon, scissors.

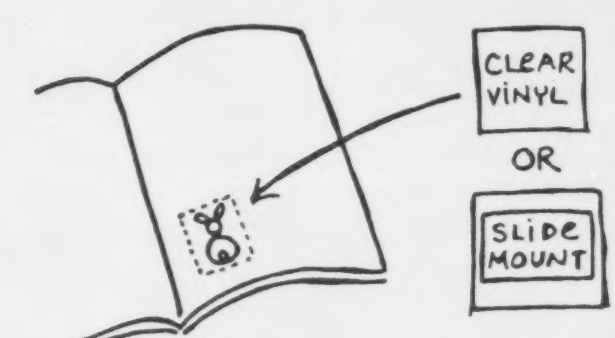
OBJECTIVES

Students will be able to make their own slides.

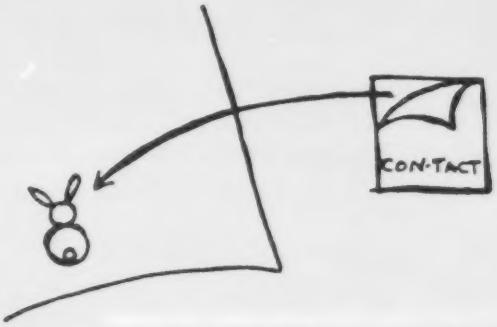
DESCRIPTION

Below is a simple 10-step procedure for making slides. This can be used as an opportunity for students to report information in any subject while satisfying a creative need at the same time.

ACTIVITIES

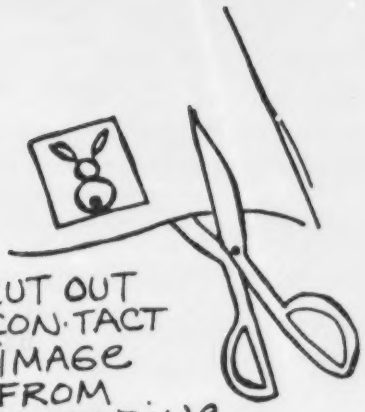


1 SELECT IMAGE (PICTURE, WORD, BACKGROUND) FROM SLICK MAGAZINE TO FIT THE VINYL SQUARE OR SLIDE MOUNT.



2 PEEL BACKING FROM CON-TACT SQUARE AND PLACE STICKY SIDE ONTO THE IMAGE YOU HAVE PICKED.

3 RUB CON·TACT IMAGE HARD WITH SPOON. MAKE SURE THAT CON·TACT MAKES GOOD, TIGHT BOND.



4 CUT OUT CON·TACT IMAGE FROM MAGAZINE.

5 SOAK IN WATER UNTIL PAPER COMES LOOSE FROM CON·TACT (USUALLY SEVERAL MINUTES).

6 EXAMINE STICKY SIDE OF CON·TACT FOR WHITE CHALKY RESIDUE. WITH FINGERS RUB THIS OFF — THIS IS CRITICAL. RINSE CLEAN.

7A NOW YOU HAVE A CHOICE FOR MOUNTING THE CON·TACT IMAGE...

IF... CLEAR VINYL

8A

PLACE CON·TACT IMAGE, DULL STICKY SIDE DOWN ONTO A VINYL SQUARE.

7B OR

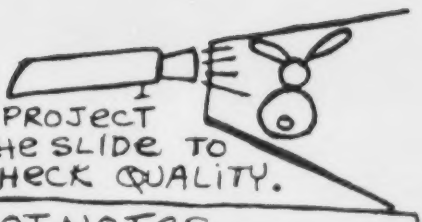
IF... SLIDE MOUNT

8B

PEEL BACKING OFF OF ANOTHER PIECE OF CON·TACT AND ADHERE STICKY SIDE TO DULL, STICKY SIDE OF CON·TACT IMAGE.

9A RUB OR PRESS TOGETHER UNTIL ALL WATER IS REMOVED. THE SLIDE IS NOW READY!

9B RUB OR PRESS TOGETHER UNTIL ALL WATER IS REMOVED. TRIM TO FIT THE SLIDE MOUNT AND INSERT INTO MOUNT. THE SLIDE IS NOW READY!



10 PROJECT THE SLIDE TO CHECK QUALITY.

FOOTNOTES

- CLEAR CON-TACT BRAND TRANSPARENT IS SOLD BY THE YARD (18" WIDTH) AT DIMESTORES, GROCERY STORES, etc. FOR ABOUT 50¢ A YARD.
- "SLICK" MAGAZINES ARE THOSE USING CLAY-COATED PAPER. LIFTING OF IMAGES WITH CON-TACT CAN BE DONE ONLY WITH THIS TYPE OF PAPER. IF IN DOUBT, TRY IT.

The suggestions and activities that follow are examples of worksheets which could be utilized in a minicourse on Photography.

"Wildlife Photography Unit," "Photography Field Trip Report Form," "Photography Vocabulary Puzzle," "Photography Jumble," and "Basic Color Theory" were all written by Vince Moragues, Westbrook Junior High School, District 66, Omaha, Nebraska.

The "Photography Review Ideas" were written by John Lincoln, Logan Fontenelle Junior High School, Bellevue, Nebraska.

The suggested course outline was written by Don Wood, Pierce High School, Pierce, Nebraska.

The names of the writters were listed here so that the materials presented may be directly xeroxed and distributed without the need for retyping the information for students.

WILDLIFE PHOTOGRAPHY UNIT

1. Pre Activities (Preparation for the field trip)

   A. Discuss and demonstrate use of 35mm cameras and accessories: (zoom telephoto, 2x coupler, close-up lenses, macro lenses, tripod, cable release, microscope adaptor, reversal ring, etc.)

   B. Prepare student worksheets on needed topics such as: SLR camera, lenses, color, composition, film, etc.

   C. Discussion topics:
      stop action
      push processing
      composition - Look at examples and discuss needed techniques
      subject matter to look for and where to look:
        decomposers, insects (crawling or winged), snakes, frogs, toads and turtles, fish, birds, mammals (deer, coyote, mice), plants, flowers, fungi, trees and leaves, succession, clouds, lightening, constellations, etc.

   D. Construction Suggestions:
      A portable blind
      A glass bottom bucket (water-tight)
      Ring stand and clamps to prevent plant specimen movement in the wind.

   E. Develop rules for photo contest:
      How many shots
      How much time to shoot

   F. Assign specific task or responsibility area to each student.

2. Field Trip (Obtain all necessary advance permission, parental permission slips, administrative input, and study the area before taking the students to familiarize yourself with specimens in the area, and any safety hazards such as barb wire fences, cliffs, etc. which students should be aware of in advance)

3. Post Activities (After the Field Trip)

   A. Develop color slides and mount them.

   B. Prepare narration with background music for an automatic-advance slide show.

C. Microscopic photography of samples of microorganisms collected:
   Use two different cameras.
   Use two different microscopes.

D. Judge contest winners and award prizes
   (film and certificates)

PHOTOGRAPHY FIELD TRIP REPORT FORM

STUDENT'S NAME _____ DATE _____

ADDRESS VISITED _____

_____

PHONE NUMBER: _____

TYPES OF PHOTOGRAPHIC BUSINESS DONE THERE:

_____

_____

_____

PHOTOGRAPHIC EQUIPMENT OR SUPPLIES OBSERVED NEVER SEEN BEFORE:

Equipment or Supplies' Name	Purpose	Cost

NAME OF PERSON CONTACTED: _____

THIS PERSON'S HELPFULNESS:

1	2	3	4	5
EXCELLENT	ABOVE AVERAGE	AVERAGE	BELOW AVERAGE	POOR

PLEASE ATTACH A COPY OF FREE LITERATURE AVAILABLE AND ATTACH BELOW CONTACT PRINTS OF PICTURES TAKEN.

PHOTOGRAPHY VOCABULARY PUZZLE

Directions: Hidden in the puzzle below are more than 45 photography terms. The terms are in a straight line horizontally, forwards or backwards, vertically, top to bottom or bottom to top and diagonally. Circle the ones you find and look up the definitions of at least 35 of them that you find and write them on the back of this sheet.

D T N I R P T C A T N O C O N T R A S T
O R O A M L O T K E D T O S M E N Z I H
U E P O L E V E D O H E M U L S I O N G
B G Y B I C R O P G L S P B L U S T F I
L R H I F C J I I N K U O L Y H R O E L
E A S E L R R L D I K C S O U D N D R S
E L A C S T N I R P N O I T C E J O R P
X N F F L A S H H P J F T T R V M D O O
P E E S I E F T R O W E I E E E M G T S
O E L T D X A U Q R R C O R F L L I Y I
S G I O E B E H O C I H N R L O I N P T
U E G P P P O R T R A I T O E P F G E I
R U C O N D E N S E R X D L X I N E P V
E Q T N E G A G N I R A E L C N A P L E
V S F R G D I A P H R A G M A G P U A F
E E A S A N U M B E R S B A M T X W T I
S G N O T Y D A R K R O O M E A I O E L
N D G P I R S W O L L E B G R N R L O T
E O D E V E L O P E R S P A A K T B X E
L D L E E R G N I P O L E V E D R Y E R

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PHOTOGRAPHY JUMBLE

(1) GENIVATE _ _ O _ _ O _ _

(2) LENSOUMI _ O _ _ _ O _ O

(3) MARRODOK _ O _ _ _ _ _ _

(4) GENERALR _ O _ O _ _ _ _

(5) SEXROPUE _ _ _ O _ _ _ _

(6) ROTTARPI _ _ _ O _ _ O _

MORE IMPORTANT THAN AN EXPENSIVE CAMERA IN TAKING A GOOD PICTURE IS

_ _ _ _ _ _ _ _ _ _ _ _.

---

(1) CUFOS _ _ _ _ O

(2) HILTG _ _ O O _

(3) TRIPN _ _ O _ _

(4) HALFS _ _ O _ _

(5) ARMACE _ O O _ O _

(6) DIPROT _ _ _ O _ O

THE PARTS OF ADJUSTABLE CAMERAS THAT ADJUST THE SIZE OF THE LENS OPENINGS: THE _ _ _ _ _ _ _ _ _ _ _. (The answer is one word.)

---

(1) PRELOVED _ _ _ _ _ O _ _

(2) CONSERNED O O _ _ _ _ _ _ _

(3) HALFIGEST _ _ _ _ _ O _ _ _

(4) GRAEONDUCK _ _ _ _ _ _ _ _ O _

(5) GRAOTHYHOPP _ _ _ O O _ _ _ _ O _

(6) RUSHETT O _ _ _ _ _ _

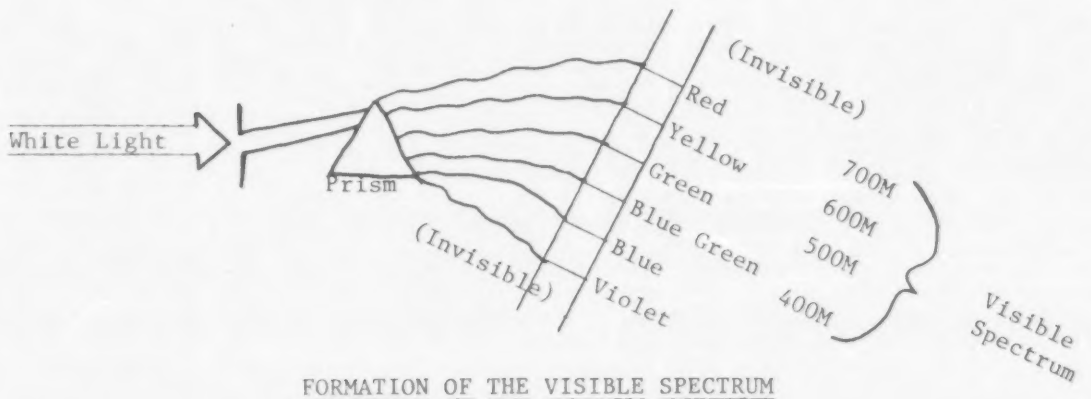
(7) MILF _ O _ O

THE PROPER SELECTION AND ARRANGEMENT OF SUBJECTS WITHIN THE PICTURE AREA IS CALLED _ _ _ _ _ _ _ _ _ _ _ _.

BASIC COLOR THEORY

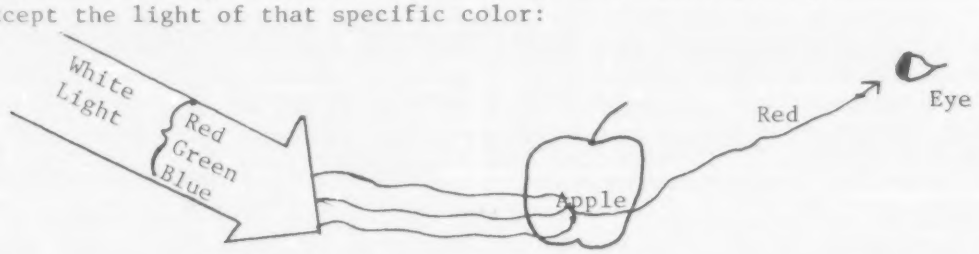
1. Whole white light is a mixture of all the different wavelengths (colors) of light in the visible spectrum.

2. Whole white light can be separated into its component colors by passing it through a glass prism or water, etc.



FORMATION OF THE VISIBLE SPECTRUM

3. Colored objects appear to be a specific color because the molecules in that object absorb all wavelengths (colors) of light except the light of that specific color:



4. The various colors of light are all composed of various amounts of three Basic Colors: red, green, and blue.

5. Equal amounts of the three basic colors when added together equal white light. red + green + blue = white light.

6. The light remaining when one of the three basic colors is removed from or filtered out of white light is called that color's Complementary color.

Basic Colors	Complementary Colors
Red	Cyan (blue and green)
Blue	Yellow (red and green)
Green	Magenta (red and blue)

7. Any color plus its complementary color in equal amounts make whole white light.

red + cyan = white
blue + yellow = white
green + magenta = white

8. Equal amounts of the three complementary colors when added together produce whole white light. cyan + yellow + magenta = white

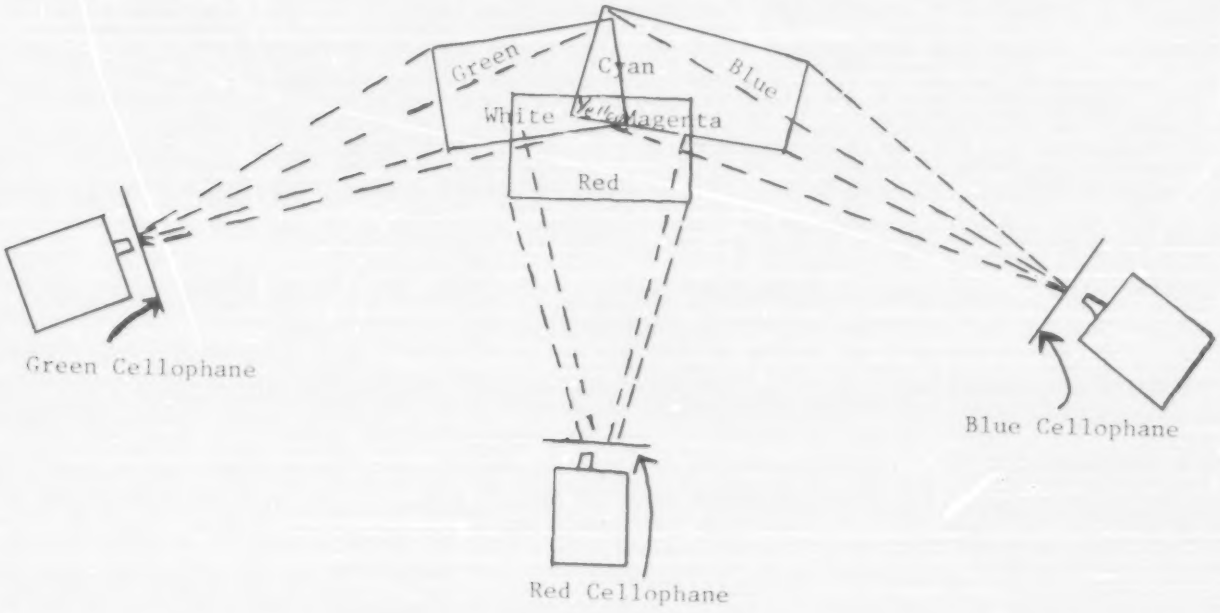
9. Any two basic colors or any two complementary colors when added together in equal amounts produce the opposite of the third basic color or the opposite of the third complementary color.

Red	Blue	Green
Cyan	Yellow	Magenta

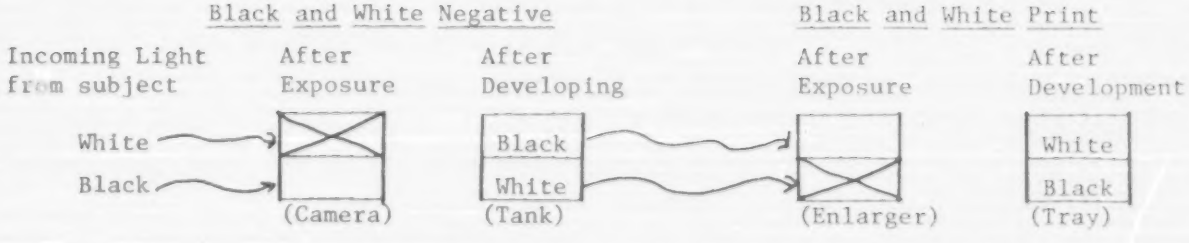
Red + Blue = Magenta
Red + Green = Yellow
Blue + Green = Cyan

Cyan + Yellow = Green
Cyan + Magenta = Blue
Yellow + Magenta = Red

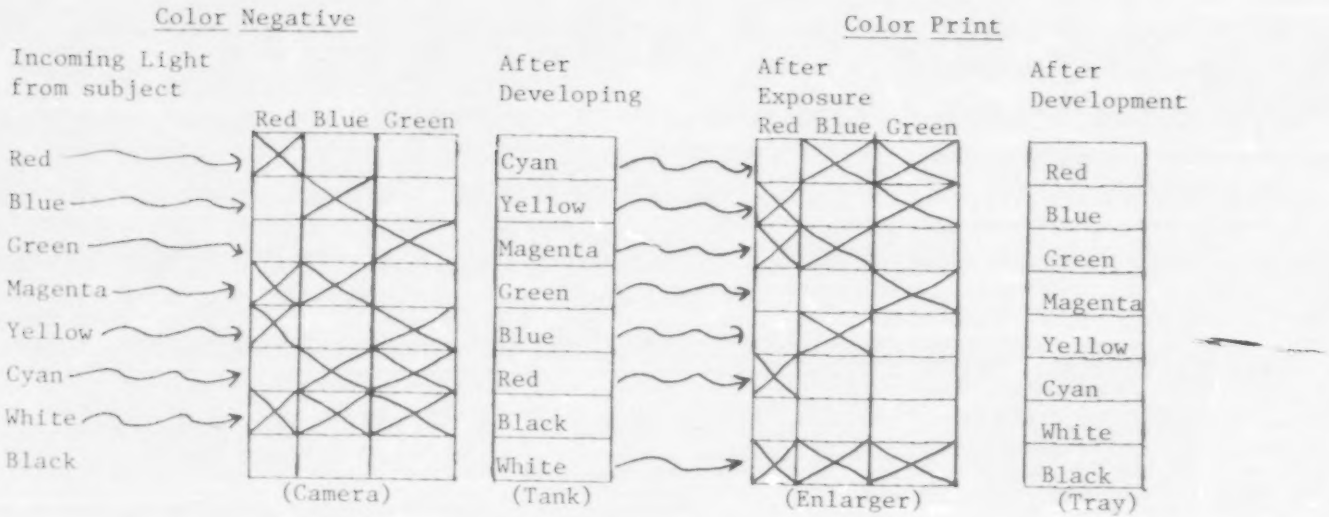
Adding Basic Colors of Light With Three Projectors:



10. Black and White and Color Negative Processes Compared

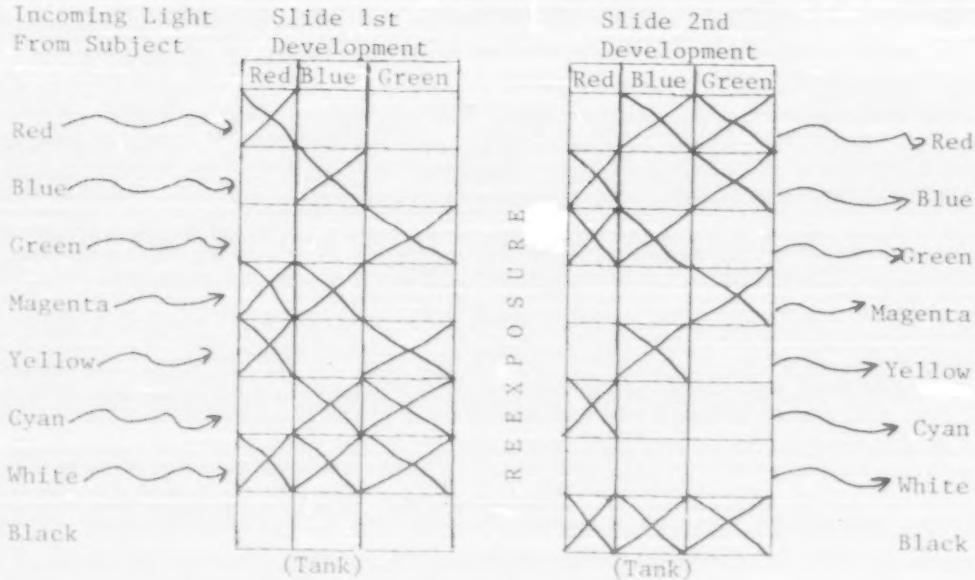


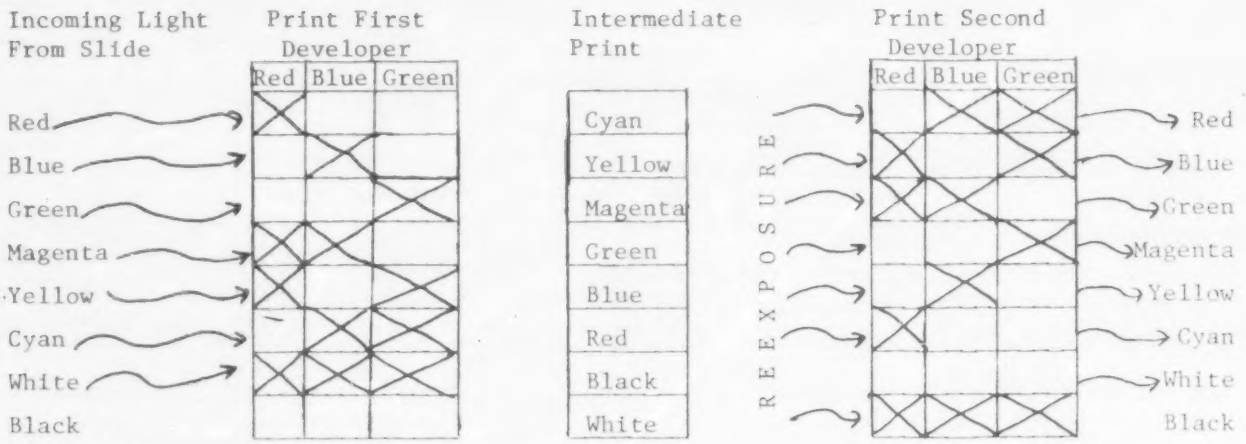
⊠ Indicates that the silver halides have been converted into metallic silver which is black after developing.



Indicates that the silver halides are converted to metallic silver which is black after developing. The colored dyes in their respective layers are then coupled or fixed permanently. Finally the dark silver is bleached out of the negative.

11. Processing Color Slides and Prints From Slides





Indicates that the silver halides in the emulsion have been converted to metallic silver which is black after developing. After the second development, the colored dyes in their respective emultion layers are coupled or fixed permanently. Finally, the dark silver is bleached out of the negative.

12. Filters Absorb Light in Different Amounts

A colored filter holds back or absorbs a certain amount of its complementary color.

Filters come in various color densities:

i.e. Yellow .05
Magenta .10
Cyan .20
Red .40

Filters can be added or subtracted, i.e.

Red .10 + Red .20 = Red .30

This is handy because the photographer does not have to buy as many filters.

The collections of filters put in the enlarger for correct color printing is called "The Filter Pack." The filter pack description, i.e. 40M + 30Y + 2B indicates both the color and the density of the individual filters in the pack.

In color printing a good rule is to always include a 2B filter in every filter pack to absorb the ultra violet light from the enlarger.

PHOTOGRAPHY REVIEW IDEAS

Composition:

1. Historical development of composition.
2. Main differences between formal and informal composition.
3. Some of the rules regarding how center of interest should be treated.
4. Rule of Thirds.
5. How balance is created by:
   a. area weight
   b. light and dark
6. How dark and light affect eye attention.
7. How depth can be created in a photograph.
8. Framing
9. Where horizon should be placed.
10. -The four mergers
11. The mood created by horizontal, vertical, diagonal, and curved lines.

Development of Negative:

1. What things make up black and white film?
2. When is silver in the form of silver halide salt?
3. When is silver in the form of metallic silver?
4. What is the purpose of the developer?
5. Why must developer be agitated?
6. What three things determine the length of time film is to be left in the developer?
7. Purpose of stop bath?
8. Purpose of fixer?
9. Purpose of hypo clearing agent?
10. Why film needs to be washed?
11. Purpose of photo flow?
12. How does a squeegee help?
13. Under what light conditions can film be loaded?
14. When is film light safe during the development process?
15. How will an underexposed negative appear after development.
16. How will an overexposed negative appear after development?

Making Proof Sheets and Printing:

1. Under what situations can a safelight be used?
2. What is the purpose of an easel?
3. What is the purpose of a lens stop on an enlarger?
4. What is a contact sheet?
5. How should paper and negative be placed when making a contact sheet?
6. What are a couple of ways a test print can be made when printing?
7. What type of rules should be used when using print tongs in chemicals?
8. What is the purpose of a negative carrier?
9. How can one tell the emulsion side of a negative?
10. How can one tell the emulsion side of paper?
11. What is the relationship between the exposure time of an over and underexposed negative?
12. When is a print light safe?
13. What is dodging?
14. What is printing in?
15. How does a negative go in an enlarger?

Camera and Exposure

1. Describe a single lens reflex camera.
2. Describe a twin lens reflex camera.
3. Describe a box camera.
4. What does a shutter of a camera do?
5. What does a diaphragm of a camera do?
6. What does ASA number in film speed mean?
7. How do we determine what speed of film to use?
8. What does aperture mean.
9. What does f/stop mean?
10. What is the relationship between size and aperture and f/stop rating?
11. What is depth of field?
12. What is the relationship between f/stop and depth of field?

COURSE OUTLINE FOR PHOTOGRAPHY

This outline is suggested for a basic black and white photography course. It is designed as a third year of science for students that do not want to take chemistry or physics. It also offers the possibility of a career and lifetime interest. Topics of study in the class include correct camera techniques, darkroom procedures, composition of pictures, and other special effects.

Course Goals:

1. The student will learn the correct techniques for using a camera.
2. The student can develop black and white film.
3. The student can print black and white pictures.
4. The student will use correct composition techniques in taking pictures.

Objectives:

The student will be able to:

1. Learn a skill that will develop into a profession or a lifetime interest.
2. Work with other people.
3. Develop a responsible attitude for the equipment and the people with whom he works.
4. Identify and explain the parts of a camera (shutter, shutter release, speed ring, f/stop ring, rewind knob, film advance lever, ASA ring, preview button, hot shoe attachment, self timer, etc.).
5. Explain relations between f/stops, shutter speeds, and amounts of light hitting the film.
6. Demonstrate proper use of a strobe or flash unit.
7. Explain the use of the Analite II in printing.
8. Determine the correct solutions used in printing black and white photos.
9. Critique and explain composition problems.
10. Describe various film types available, their unique uses, and their developing processes.

Course Content:

Unit 1: The Camera

A complete and detailed study of the different types of cameras including 110, 126, 35mm, 120, large format, and other special cameras. The students will learn correct techniques for using the common types of cameras. Emphasis will be placed on correct composition of the pictures.

TOPICS:
A. Types, parts, and functions of the camera
B. Correct usage
C. Camera tricks
D. Composing the picture
E. Camera systems

Unit 2: Film Developing

The different types of film and their usages are studied. Developing black and white film, using correct procedures and trouble-shooting will be accomplished in this unit.

TOPICS:
A. Film types and uses
B. Darkroom skills
C. Solution usage
D. Developing techniques and problems

Unit 3: Printing

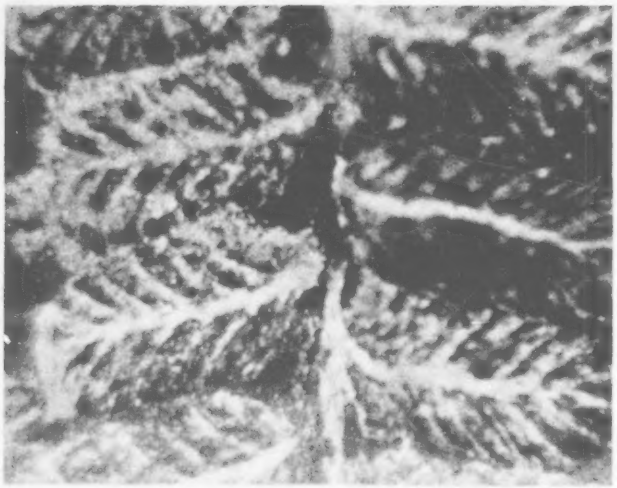
This unit studies the enlarger, the types of paper, and the solutions used to process the paper into prints. Considerable time is spent in the darkroom learning good enlarging techniques and special effects that can be added.

TOPICS:
A. Enlarger usage
B. Solutions
C. Darkroom techniques
D. Developing tricks

Unit 4: Special Interests

This is an area for individual experimentation. Students can do their own discovery and experimentation with color prints, color slides, and advanced black and white techniques.

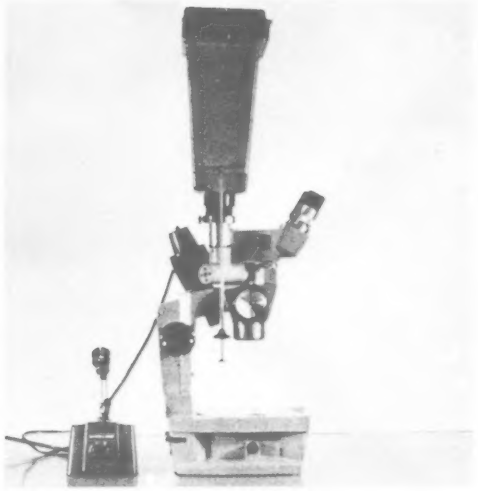
TOPICS:
A. Special black and white techniques
B. Color slide developing
C. Color negative and print developing



A

B

Figure 5: Close-up photography. (a) Close-up photograph of a very small fossilized plant taken with a 55mm lens (mounted in reverse, see page 22) mounted on a bellows attachment (enlarged 12.3X). (b) A sturdy tripod is used to hold a 35mm camera fitted with a bellows attachment to get extreme close-up photographs. The platform jack pictured makes a useful accessory for positioning small specimens when taking extreme close-up photographs.



A

B

Figure 6: Apparatus used to photograph small specimens with a Polaroid camera. (a) A dissecting microscope outfitted with an inexpensive Polaroid camera that can provide a finished picture within a minute or less. (b) Photograph of a flea head that was taken with a setup similar to the one shown on the left.